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PROCEEDINGS
OF THE
BIOLOGICAL SOCIETY OF WASHINGTON

SHALLOW-WATER SEA CUCUMBERS
(ECHINODERMATA: HOLOTHUROIDEA)
FROM CARRIE BOW CAY, BELIZE¹

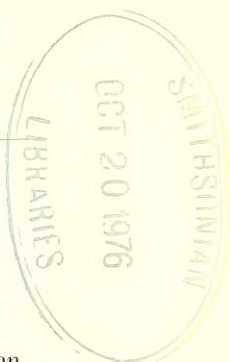
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In a recent article on the echinoderms of British Honduras (Belize), Devaney (1974) described a fauna of 34 species, of which only one, the synaptid *Euapta lappa* (Muller), was a holothurian. During the Smithsonian Institution's Investigations of Marine Shallow Water Ecosystems (I.M.S.W.E.) Project, based largely at Carrie Bow Cay, Belize (16°48'N, 88°05'W), participating investigators have made general collections of invertebrates, and these include 12 species of holothurians, of which 3 species of the genus *Leptosynapta* are new. In this paper the new species are described, other species are briefly characterized and some illustrated, and a key to all species is provided. A brief description of Carrie Bow Cay habitats can be found in Dahl (1973). All specimens were collected from Carrie Bow Cay, unless otherwise indicated in the species accounts. They were sampled by wading and skin diving in less than 2 m water depth.

Kier (1975) described the echinoids of Carrie Bow Cay, and added a further 13 species to the 7 listed by Devaney. Thus, the total number of echinoderms now reported from Belize is 58. As is to be expected, the fauna is typically Caribbean in character. For the holothurians some interesting new range extensions are reported. No dendrochirotid

¹ Contribution No. 30 of the Investigations of Marine Shallow Water Ecosystems (I.M.S.W.E.) Project, Smithsonian Institution.



plates with well developed bridge for support of anchors.

Active, conspicuous forms; generally non-burrowing.

- 15 (16) Grey to brown, often longitudinally striped. Body wall often with characteristic hemispherical "bumps." Stock of anchor branched *Euapta lappa* (Müller)
- 16 (15) Green and white mottled or brown and white mottled. No "bumps" on body wall. Stock of anchor unbranched *Synaptula hydriformis* (Lesueur)
- 17 (14) Arms of anchors with teeth; no knobs on vertex. Anchor plates lack true bridge. Inconspicuous burrowing forms.
- 18 (19) Anchors and anchor plates very large, anchors usually exceeding 600 μm in length, plates usually exceeding 400 μm *Leptosynapta imswi* Pawson
- 19 (18) Anchors and anchor plates do not exceed 200 μm in length.
- 20 (21) Anchors and anchor plates very small, considerably shorter than 130 μm . Miliary granules resemble rosettes *Leptosynapta nannoplax* Pawson
- 21 (20) Anchors and anchor plates larger, usually exceeding 140 μm in length. Miliary granules more or less C-shaped, with enlarged ends, not resembling rosettes *Leptosynapta roseogradia* Pawson
- 22 (13) Skin more or less smooth, but with numerous scattered papillae containing aggregations of wheels. Brick red to pink *Chiridota rotifera* (Pourtales)

Actinopyga agassizii (Selenka)

Figures 1C, E

Actinopyga agassizii.—Deichmann, 1930, 78, pl. 5, figs. 21–29.

Material examined: Lagoon, west of island, coral sand and turtle grass, 19 April 1972, collected R. J. Larson, 1 specimen; lagoon, April 1974, 1 specimen; Coral berm, 3 May 1974, collected by B. Spracklin, 1 specimen; back reef, 1–2 m, April 1975, collected by M. Carpenter, 2 specimens.

Remarks: Grows to about 20 cm. Five conspicuous calcareous "teeth" surround the anus. Skin thick, leathery. Numerous tube feet dorsally and ventrally. Color variable, but usually with mottled brown and yellow predominating. Tentacles yellow.

Common on sand in grassy areas in shallow water around islands of the West Indies, from Barbados to Florida. One record from Bermuda. The record from Belize is a new range extension into the Western Caribbean.

Holothuria impatiens (Forskaal)

Holothuria impatiens.—Deichmann, 1930:64, pl. 3, figs. 17, 18.

Material examined: Just inside reef crest, 7 May 1974, collected by F. H. C. Hotchkiss and K. Sandved, 2 specimens; lagoon, west side

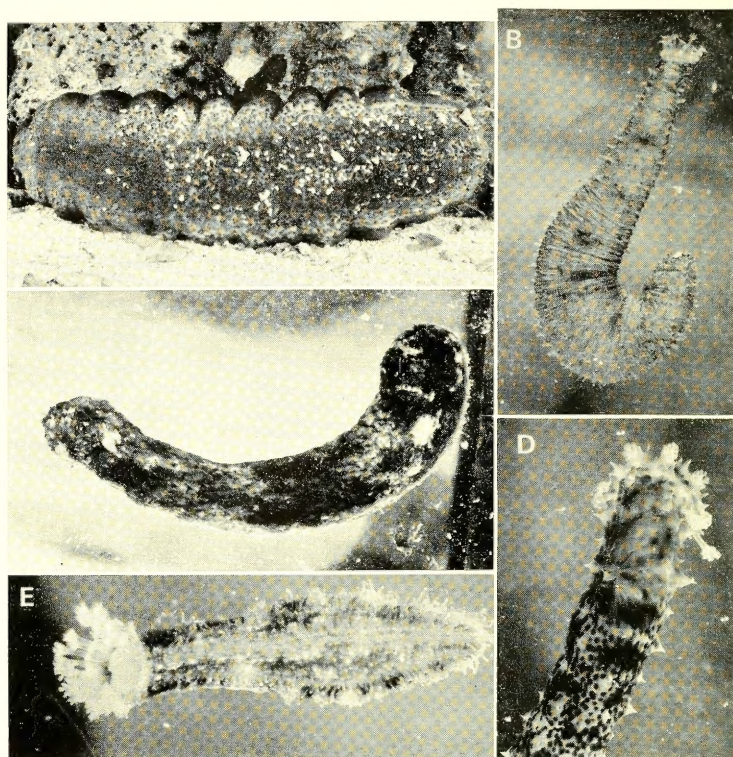


FIG. 1. A, *Holothuria mexicana*, ventral; B, *Holothuria arenicola*, dorsal; C, *Actinopyga agassizii*, dorsal; D, *Isostichopus macroparetheses*, anterior dorsal; E, juvenile *Actinopyga agassizii*, ventral.

of island, coral sand, turtle grass, under conch shells, 19 April 1972, collected by R. J. Larson, 1 specimen.

Remarks: Grows to about 20 cm. Tube feet few, scattered, placed on distinct warts, at least dorsally. Skin thin, rough to touch. Color grey with brownish patches.

A "tropicopolitan" species, often uncommon or rare where it occurs. Usually found on sand or in grassy areas.

Holothuria arenicola Semper

Figure 1B

Holothuria arenicola.—Deichmann, 1930:66, pl. 4, figs. 1–9.

Material examined: Under conch shells, foot of pier, 29 April 1974, collected by F. H. C. Hotchkiss and K. Sandved, 1 specimen; lagoon,

west side of island, near shore, 1 May 1974, collected by F. H. C. Hotchkiss and K. Sandved, 1 specimen; lagoon along west shore of island, low tide, 30 April 1972, collected by R. J. Larson, 1 specimen; back reef, 1–2 m, 1975, collected by K. Sandved, 1 specimen; same locality, 22 April 1975, collected by M. Carpenter, 2 specimens; same locality, 27 April 1975, collected by M. Carpenter, 1 specimen.

Remarks: Grows to about 30 cm. Body slender, fusiform, with very small tentacles. Adapted to a burrowing habit, and often found concealed under rocks and shells. Skin relatively thin and smooth to the touch. Ground color usually light brown, with dark brown patches in 2 series on dorsal surface. Color can vary considerably, probably depending upon chemical properties of the habitat; rust-colored to almost black specimens occur in some areas of the Caribbean.

A "tropicopolitan" species, commonly encountered in suitable habitats.

Holothuria mexicana Ludwig

Figures 1A, 2A

Holothuria mexicana.—Deichmann, 1930:74, pl. 5, figs. 15–20.

Material examined: Lagoon, south end of island, 1 specimen; May 1974, collected by F. H. C. Hotchkiss, 1 fragment; back reef, immediately behind crest, 1–2 m, April 1975, collected by M. Carpenter, 2 specimens.

Remarks: Grows to about 50 cm. Skin very thick, smooth, extremely hard when contracted. In life, body dark brown to blackish dorsally, with flanks yellowish brown, and ventral surface frequently reddish or pink. The reddish to pink ventral coloration disappears in alcohol. The specimen from station 1 above is unusual in being very light brown dorsally. The smaller specimen from the back reef is 110 mm in total length. The ground color is greyish white; ventral feet are light brown with dark brown endplates; dorsal surface with light brown feet and a double row of 4 large dark brown blotches. Deichmann (1930:74) noted that young specimens of this species have similar coloration, but she did not mention the presence of large dark blotches dorsally.

Ranges from Cuba to Curaçao in shallow water (to 20 m) in grassy areas or on muddy sand. This species has been frequently confused with the closely related *H. floridana* Pourtales.

Isostichopus badionotus (Selenka)

Stichopus badionotus.—Deichmann, 1930:80, pl. 5, figs. 30–36.

Material examined: Lagoon, west side of South Water Cay, mixed sand and *Thalassia*, 1 m depth, 4 May 1974, collected by F. H. C. Hotchkiss and K. Sandved, 1 specimen; Coco-Plum Cay, at edge of mangrove swamp, 2 May 1972, collected by R. J. Larson, 1 specimen;

lagoon, west side of island, coral sand, turtle grass, under conch shells, 19 April 1972, collected by R. J. Larson, 1 specimen.

Remarks: Grows to about 20 cm. Skin thick, with low warts dorsally and 3 crowded rows of tube feet ventrally. Color highly variable, from light brown to black, usually with numerous large spots or blotches of dark brown on a lighter background.

Common on muddy sand or in grassy areas, in shallow water, from Bermuda to Panama.

Isostichopus macroparentheses (Clark)

Figure 1D

Stichopus macroparentheses H. L. Clark, 1922:61, pl. 4, figs. 1-7; Deichmann, 1930:82, pl. 5, figs. 37-43; H. L. Clark, 1933:110 [*macroparentheses*].

Isostichopus badionotus.—Deichmann, 1963:106.

Material examined: Back reef, 1-2 m, April 1975, collected by M. Carpenter, 1 specimen.

Remarks: Grows to about 12 cm. In the field, virtually indistinguishable from *I. badionotus*, and can be positively identified only after examination of the spicules. Deichmann (1963) was inclined to regard *I. macroparentheses* as a juvenile stage of *I. badionotus* which has exceptionally large C-shaped ossicles. The difference between these C-shaped ossicles in the two forms is dramatic, particularly when one compares juveniles of *I. badionotus* with *I. macroparentheses*. I cannot agree with Deichmann's contention, and thus prefer to retain *I. macroparentheses* as a separate species.

In life, "bright brown, with very dark rings around the bases of the papillae which have yellow tips" (Clark, 1933:110). The present specimen is 30 mm long. Color photograph shows light brown body with dark brown dorsal feet and light to dark brown ventral feet; tentacles are more or less colorless.

The species is also known from Antigua, Jamaica and the Tortugas, in shallow water.

Euapta lappa (Muller)

Figure 2B

Euapta lappa.—H. L. Clark, 1924:464, pl. 1, figs. 5-7; 1933:118.

Material examined: Lagoon, 2 specimens; just inside reef crest, 6 May 1974, collected by F. H. C. Hotchkiss and K. Sandved, 1 specimen; reef flat, south end, east side of island "Penicillus" rock zone, 1 specimen; lagoon, west side of island, coral sand, turtle grass, under conch shells, 19 April 1972, collected by R. J. Larson, 2 specimens.

Remarks: Grows to about 100 cm. Color grey to brown, often longitudinally striped. Body wall prickly to touch, owing to presence

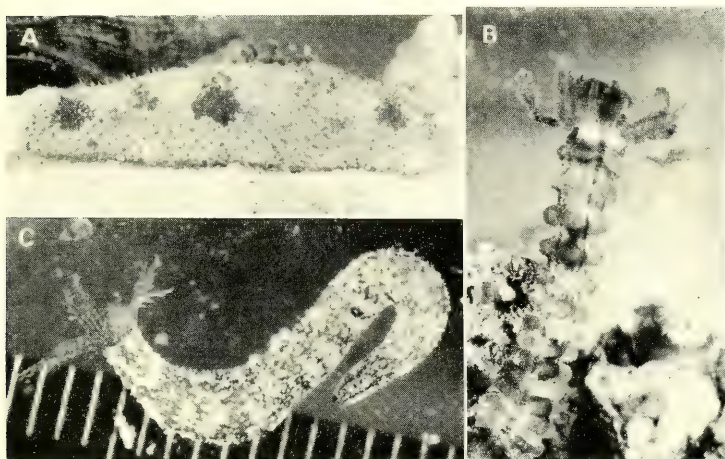


FIG. 2. A, young *Holothuria mexicana*, lateral; B, *Euapta lappa*, anterior dorsal; C, *Synaptula hydriformis*, dorsal.

of projecting spicules (anchors). Tentacles plume-like. Body often displays rows of characteristic conspicuous hemispherical protuberances.

An active reef-dwelling form often associated with lumps of dead coral. Can swim to a limited extent. Ranges the entire Caribbean in shallow water.

Synaptula hydriformis (Lesueur)

Figure 2C

Synaptula hydriformis.—H. L. Clark, 1924:473, pl. 3, figs. 5, 6, pl. 4, fig. 4; 1933:119.

Material examined: Foot of boat pier, bulk sample no. 2, 29 April 1974, collected by F. H. C. Hotchkiss and K. Sandved, 8 specimens; just inside reef crest, 6 May 1974, collected by F. H. C. Hotchkiss and K. Sandved, 1 specimen; back reef, 1–2 m, April 1975, collected by K. Sandved, 1 specimen.

Remarks: Grows to about 10 cm. Prickly to touch due to projecting spicules (anchors). Two color phases, mottled green and white and mottled brown and white, can occur. Some correlation exists between habitat type (red or brown or green algae frequently) and color of body wall, but exceptions occur; for example, in Bermuda the brown form is conspicuous among clumps of the green *Penicillus*. Green form only known so far from Carrie Bow Cay. Viviparous; apparently can breed all year round in Bermuda.

Ranges from Bermuda to Brazil. Usually found in weed in shallow water.

Leptosynapta Verrill, 1867

The Carrie Bow Cay collections contain a total of 11 complete specimens and several fragments of synaptids which can be referred to the genus *Leptosynapta*. Surprisingly, the specimens represent 3 new and distinctive species. While I am reluctant to describe 3 further species in a genus which is already quite large (approximately 25 species) and requires revision, it is clear that under currently accepted taxonomic criteria for the family Synaptidae, the present species must be regarded as new. It seems likely that further collecting in sandy areas of the Caribbean will reveal a large and diverse fauna of burrowing synaptids; such habitats have received very little attention from collectors in the past.

The 3 species described below do not appear to be closely related to one another, but each shares some important features with other western Atlantic congeners.

***Leptosynapta imswi*, new species**

Figure 3

Diagnosis: Anchors and anchor plates of one kind, very large, anchors usually exceeding 600 μm in length, plates exceeding 400 μm in length. Miliary granules numerous, in form of C-shaped rods with enlarged ends.

Material examined: Holotype (USNM E15854, specimen 57 mm long), lagoon, sand, north end, west side of Carrie Bow Cay, Belize, 27 April 1974, collected by F. H. C. Hotchkiss and K. Sandved. Paratypes 3 complete specimens and 11 fragments (USNM E15855) from same locality as holotype.

Etymology: The species is named for the Smithsonian Institution I.M.S.W.E. program (Investigations of Marine Shallow Water Ecosystems).

Description: Total length ranges from 7 to approximately 90 mm; probably species exceeds 120 mm in life. Specimens uniformly whitish, body wall translucent when expanded; color in life pink to light brown. Conspicuous anchors project through body wall rendering specimens very prickly to touch. Tentacles 12, each with 5–6 pairs of digits and a terminal digit; digits increase in length distally, and terminal digit is longest (Fig. 3F). Inner (oral) surfaces of tentacles with double row of well developed sensory cups.

Body wall deposits comprise large anchors and anchor plates of one kind, and numerous miliary granules. Anchors and plates at anterior, middle and posterior of body wall essentially similar, although developmental stages of these ossicles more numerous posteriorly. Anchors average 630 μm in length (standard deviation 2.49; standard error 0.83), 374 μm in width, arm-tip to arm-tip (standard deviation 2.01; standard error 0.67), 126 μm in width of stock (standard de-

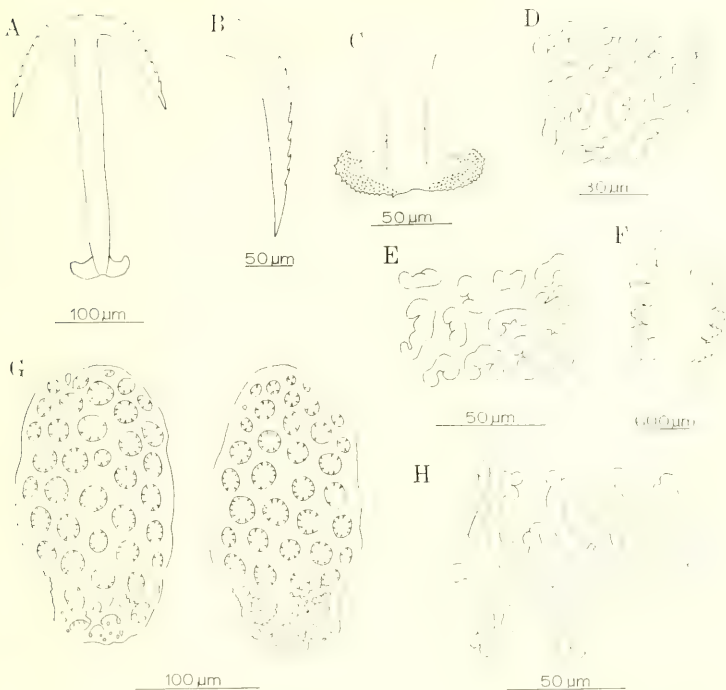


FIG. 3. *Leptosynapta imswae* n. sp. A, Anchor; B, Detail of anchor arm; C, Detail of anchor stock; D, Miliary granules from body wall; E, Ossicles from tentacle stem; F, Outline of tentacle; G, Anchor plates; H, Ossicles from tentacle digits.

viation 1.26; standard error 0.42). Arms carry up to 10 conspicuous sharp teeth. Stock unbranched, but equipped with numerous small sharp projections (Fig. 3A–C). Anchor plates elongate, approximately oval, with numerous toothed perforations (Fig. 3G); central perforations tend to be larger than others. No true bridge for support of anchors, but in area of support, anchor plate strengthened by having an irregular “pseudo-bridge” in form of a double layer of calcite. Anchor plates average 447 μm in length (standard deviation 3.09; standard error 1.03), and 246 μm in greatest width (standard deviation 0.84; standard error 0.28). Miliary granules numerous everywhere in body wall, highly variable in shape, but generally tending to have enlarged, recurved ends. Granules up to approximately 30 μm in length (Fig. 3D).

Stems of tentacles with ossicles similar to miliary granules of body wall but tending to be slightly smaller (Fig. 3E). In tentacle digits

ossicles tend to be more elongate, length up to 45 μm , and some have perforated ends (Fig. 3H).

Remarks: This is one of the few species of *Leptosynapta sensu lato* which has very large anchors and anchor plates. *L. acanthia* H. L. Clark, known only from Bermuda, has anchors and plates which are similar in size to those in *L. imswe*, but the plates have fewer perforations, and further, *L. acanthia* has numerous small anchors 140–210 μm in length and plates of approximately the same size (Clark, 1924:478); such deposits are apparently lacking from *L. imswe*. *L. multipora* H. L. Clark also has large anchors and plates but lacks the numerous miliary granules.

***Leptosynapta roseogradia*, new species**

Figure 4A–D

Diagnosis: Anchors of one type, usually less than 200 μm long, anchor plates of one type, usually less than 160 μm long. Miliary granules C- or bracket-shaped, numerous. Radial pieces of calcareous ring perforated for radial nerve.

Material examined: Holotype (USNM E15856, specimen 36 mm long), lagoon, sand, north end, west side of Carrie Bow Cay, Belize, 27 April 1974, collected by F. H. C. Hotchkiss and K. Sandved. Paratypes 3 specimens (USNM E15857) from same locality as holotype.

Etymology: The species is so named to indicate its superficial similarity to *Epitomapta roseola*.

Description: Total length 16, 26, 36, and 40 mm. Specimens white to yellowish, body wall thin, translucent; color in life pink to light brown. Tentacles 12, each with 5–6 pairs of digits and a terminal digit, which is longest. Sensory cups present in small numbers on oral surface of tentacles.

Radial pieces of calcareous ring perforated for passage of radial nerve. Ciliated funnels all of one type, small, approximately 100 μm in length.

Deposits in body wall anchors, anchor plates and numerous miliary granules. Anchors and plates at anterior, middle and posterior of body essentially similar, but differing in dimensions:

Anterior	anchors	length	167 μm	S.D. 1.36	S.E. 0.43
	plates	length	154 μm	S.D. 1.29	S.E. 0.42
Mid-body	anchors	length	192 μm	S.D. 2.6	S.E. 0.93
	plates	length	182 μm	S.D. 3.6	S.E. 1.29
	plates	width	142 μm	S.D. 2.46	S.E. 0.89
Posterior	anchors	length	148 μm	S.D. 1.32	S.E. 0.44
	plates	length	144 μm	S.D. 1.42	S.E. 0.45

Anchors (Fig. 4A) have 1–3 serrations on arms; stock with numerous small teeth. Anchor plates (Fig. 4D) approximately oval, with 7

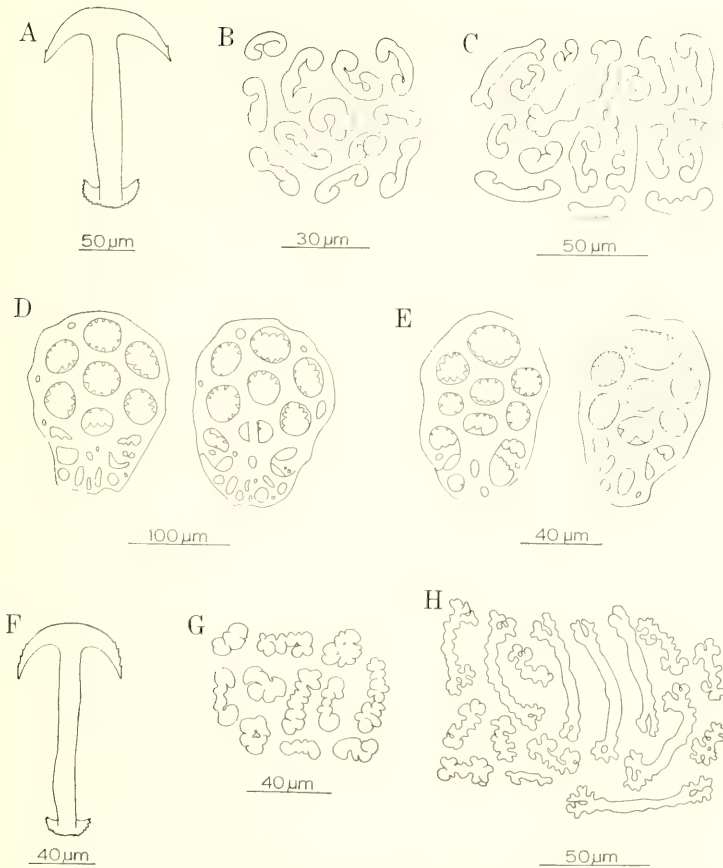


FIG. 4. *Leptosynapta roseogradia* n. sp. A, Anchor; B, Miliary granules from body wall; C, Ossicles from tentacle stems and digits; D, Anchor plates. *Leptosynapta nannoplax* n. sp. E, Anchor plates; F, Anchor; G, Miliary granules from body wall; H, Ossicles from stems and digits of tentacles.

major perforations, always toothed, also with varying numbers of smaller perforations. Plate distinctly narrower at articular end, with several small perforations. No true supporting bridge for anchor. Body wall with minute miliary granules (Fig. 4B) more or less C- or bracket-shaped, with enlarged ends. Size variable, largest granules approximately 25 μm in length.

Tentacle stems and digits contain granules similar to those in body

wall, and digits in particular have more elongate rods (Fig. 4C) up to 60 μm in length.

Remarks: This is another distinctive species of *Leptosynapta*. The anchors and anchor plates strongly resemble those of *Epitomapta roseola* (Verrill) from Woods Hole, Bermuda, and Jamaica, but *E. roseola* has imperforate radial pieces in the calcareous ring, ciliated funnels of two types, and anchor plates which are considerably smaller (110 μm , Heding, 1928:237) than those of *L. roseogradia*. Within the genus *Leptosynapta*, *L. tenuis* (Ayers) from the north-eastern United States shares some features with this new species, but differs in having larger anterior and posterior anchors, smaller anterior anchor plates, and differently shaped miliary granules and tentacle rods. Further, in *L. tenuis*, the anterior and posterior anchors are distinctly different in appearance, a feature not observed in *L. roseogradia*.

***Leptosynapta nannoplax*, new species**

Figure 4E-H

Diagnosis: Anchors and anchor plates very small, anchors usually less than 125 μm in length, anchor plates usually less than 90 μm in length. Miliary granules resemble rosettes.

Material examined: Holotype (USNM E15858, specimen 31 mm long), lagoon, sand, north end, west side of Carrie Bow Cay, Belize, 27 April 1974, collected by F. H. C. Hotchkiss and K. Sandved. Paratypes 2 specimens (USNM E15859) from same locality as holotype.

Etymology: The specific name is derived from Greek *nannos* small, and *plax*, a plate, in reference to the diminutive ossicles in the body wall.

Description: Total length of 3 specimens 26, 27 and 31 mm. Species may exceed 50 mm in life. Specimens white, body wall translucent; color in life pink to light brown. Twelve pinnate tentacles, with 3-5 pairs of digits and a terminal digit which is the longest. Sensory cups present on oral surface of tentacles.

Body wall ossicles comprise very small anchors and anchor plates of one kind, and minute miliary granules. Anchors and plates at anterior, middle, and posterior of body similar, but differing slightly in dimensions:

Anterior	anchors	length	86 μm	S.D. 0.79	S.E. 0.25
	plates	length	83 μm	S.D. 0.51	S.E. 0.16
Mid-body	anchors	length	107 μm	S.D. 4.36	S.E. 1.53
	plates	length	90 μm	S.D. 1.91	S.E. 0.64
	plates	width	61 μm	S.D. 1.62	S.E. 0.51
Posterior	anchors	length	124 μm	S.D. 0.70	S.E. 0.22
	plates	length	88 μm	S.D. 0.71	S.E. 0.24

Anchors carry up to 4 or 5 distinct serrations on arms; stock is toothed but not strongly so (Fig. 4F). Anchor plates elongate oval, usually with 7 large dentate perforations, and several smaller holes at anchor support area (Fig. 4E). No true bridge for anchor support, but usually a double layer of calcite is more or less well developed. Miliary granules scattered, usually less than 40 μ m in length (Fig. 4G). They bear close resemblance to rosettes found in other groups of apodous holothurians.

Tentacle stems and digits contain numerous deposits similar to miliary granules of body wall; in addition, digits in particular contain elongate rods up to approximately 70 μ m in length (Fig. 4H).

Remarks: Very few species of *Leptosynapta* have anchors and plates of such small size, and apparently none have miliary granules which resemble rosettes in combination with small anchors and plates. *L. micropatina* Heding from Tobago has anchors and plates of the same order of size as *L. nannoplax*, but does not possess the rosette-like miliary granules. Further, the anchor plates of *L. micropatina* usually contain smaller perforations at the wider ends of the plates in addition to the larger dentate perforations; these are lacking from *L. nannoplax*.

In view of the relatively small size of *L. nannoplax*, it is conceivable that this is the young form of a known species; if this is the case, then it is to be expected that the rosette-like miliary granules disappear or are supplanted by granules of a different type as the animal grows.

Chiridota rotifera (Pourtales)

Chiridota rotifera.—Heding, 1928:293, figs. 59, 60; H. L. Clark, 1933: 122.

Material examined: Foot of pier, bulk sample no. 2, 29 April 1974, collected by F. H. C. Hotchkiss and K. Sandved, 5 specimens; subtidal, bulk sample, 28 April 1974, collected by F. H. C. Hotchkiss and K. Sandved, 1 specimen; back reef, in conch shell, 1 m depth, 27 April 1975, collected by K. Sandved, 1 specimen.

Remarks: Grows to about 10 cm. Body smooth to touch, with more or less conspicuous aggregations of calcareous spicules ("wheel papillae") scattered in rows along the interradial areas, especially dorsally. Ground color light brick-red to pink. Viviparous.

Common on sand under rock in shallow water; also occurs in sandy beaches. Ranges from Brazil to Bermuda.

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PROCEEDINGS
OF THE
BIOLOGICAL SOCIETY OF WASHINGTONA NEW TROGLOBITIC CRAYFISH (DECAPODA,
CAMBARIDAE) FROM PENINSULAR FLORIDA

BY HORTON H. HOBBS, JR., AND DAVID S. LEE

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Several previously undescribed species of troglobitic crayfishes have been reported recently from Florida. Hobbs (1971) described *Procambarus* (*Leconticambarus*) *milleri*, the first new form recorded since 1942 (when he reviewed the crayfishes of the state). At this time (1971), he summarized the known ranges, provided a key, and illustrated the diagnostic features of all of the troglobitic species known to occur in Florida. Since then, three additional crayfishes have been named: *Procambarus* (O.) *orcinus* Hobbs and Means (1972:394), *P.* (O.) *horsti* Hobbs and Means (1972:401), and *P.* (O.) *erythropros* Relyea and Sutton (1975:8). Accompanying the description of the latter was a revised key to the troglobitic crayfishes of the state prepared by Hobbs. The species described here brings the total number of known Floridian troglobitic crayfishes to 11, all except two of which are members of the genus *Procambarus*.

We take pleasure in naming this crayfish in honor of Richard Franz, a colleague, friend, and outstanding student of cave ecosystems. His continued interest and support of this study are greatly appreciated.

We wish to thank Sylvia Scudder, Richard Bradley, Barbara Lee, and Richard Franz for their assistance in collecting the specimens on which the following description is based. We also wish to acknowledge the assistance of John E. Cooper who provided useful information leading to

Franz's initial location of Orange Lake Cave, the source of our specimens. For their critical reading of the manuscript, we are grateful to Thomas E. Bowman, Martha R. Cooper, and Margaret A. Daniel.

***Procambarus (Ortmannicus) franzi*, new species**

Diagnosis: Albinistic, eyes without pigment or faceted cornea. Rostrum with, or more often without, marginal spines; median carina absent. Carapace with cervical spine cephaloventral to row of spines or tubercles flanking caudal margin of cervical groove. Areola 12.8 to 17.2 times as long as broad and constituting 38.7 to 41.0% of total length of carapace (47.1 to 49.5% of postorbital carapace length). Suborbital angle absent. Postorbital ridge with cephalic spine. Hepatic area with many small tubercles, some spiniform. Antennal scale approximately twice as long as wide, broadest slightly distal to midlength. Ischia of third and fourth pereopods of first form male with simple hooks, that on third overreaching basioischial articulation and that on fourth highly arched, almost reaching basioischial articulation, and opposed by low eminence on basis; coxa of fourth pereopod with prominent oblique boss. First pleopod of first form male reaching coxa of third pereopod, asymmetrical, provided with subapical setae; distal extremity bearing subspiculiform mesial process directed caudally at approximately right angle to shaft of appendage and curved laterally; cephalic process rather short, acute, somewhat hooding central projection cephalically, and directed caudodistally; caudal element consisting of inconspicuous, caudolaterally situated caudal knob, and prominent, corneous adventitious process caudomesially, latter distally rounded, convex mesially, and somewhat concave laterally; and corneous beaklike central projection, most conspicuous of terminal elements, directed caudodistally subparallel to cephalic process. Annulus ventralis freely movable, subspindle-shaped, slightly more than twice as broad as long, and completely exposed, not (partly) hidden by projections from sternum immediately cephalic to it; cephalic area with convex elevated area bearing submedian J-shaped furrow; sinus originating in furrow and, following sinuous curve caudally, terminating to side of median line slightly caudal to midlength of annulus. Postannular plate slightly more than half as wide and half as long as annulus with cephalic region somewhat inflated. First pleopod in female moderately well-developed.

Holotypic Male, Form 1: Cephalothorax (Fig. 1a, l) subcylindrical. Abdomen narrower than thorax (10.1 and 13.1 mm). Greatest width of carapace greater than height at caudodorsal margin of cervical groove. Areola 14.7 times as long as wide with 1 or 2 punctations across narrowest part. Cephalic section of carapace approximately 1.5 times as long as areola, length of latter 40.7% of entire length of

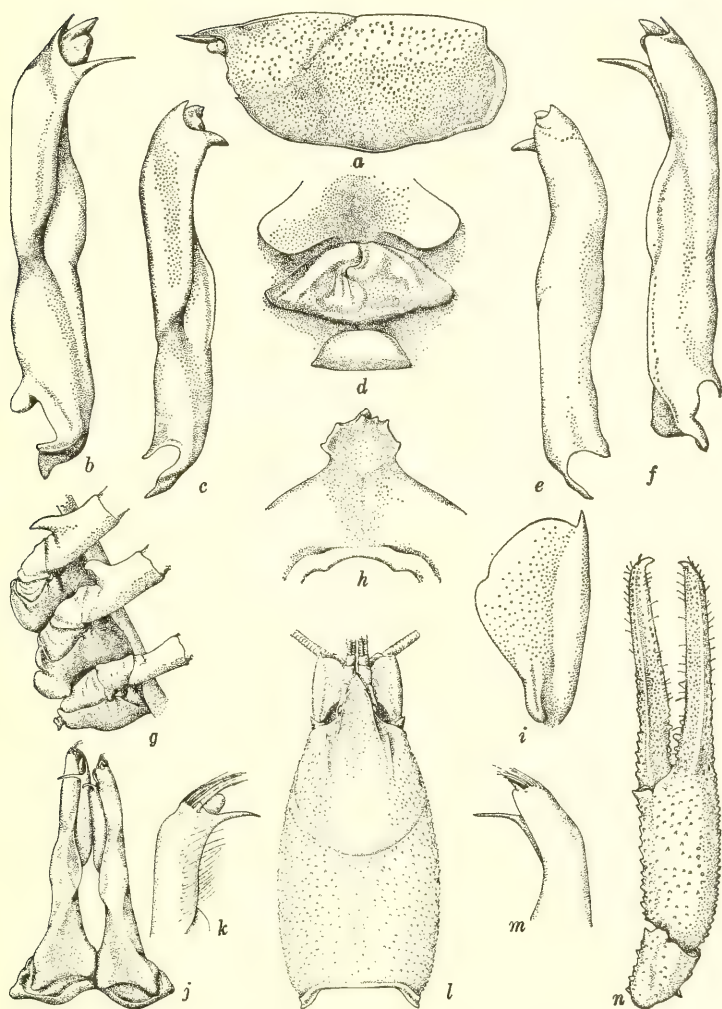


FIG. 1. *Procambarus (Ortmannicus) franzi*, new species (all illustrations are of holotype except *c* and *e* of morphotype, and *d* of allotype): *a*, Lateral view of carapace; *b*, *c*, Mesial view of first pleopod; *d*, Annulus ventralis; *e*, *f*, Lateral view of first pleopod; *g*, Basal podomeres of third, fourth, and fifth pereopods; *h*, Epistome; *i*, Antennal scale; *j*, Caudosinistral view of first pleopods; *k*, *m*, Mesial view of terminal part of first pleopod showing subterminal setae; *l*, Dorsal view of carapace; *n*, Dorsal view of distal podomeres of cheliped.

carapace (47.9% of postorbital carapace length). Rostrum with gently convergent margins, lacking marginal spines or tubercles but with broad-based acumen clearly delimited by mesially curved cephalic ends of rostral margins. Acumen reaching midlength of penultimate segment of antennular peduncle; dorsal surface shallowly excavate and sparsely punctate. Subrostral ridge rather weak and evident in dorsal aspect along caudal three-fifths of rostrum. Postorbital ridges well-developed, grooved dorsolaterally, and terminating cephalically in small spine, more posterior spines lacking. Caudodorsal margin of cervical groove with row of spiniform tubercles, ventralmost member of row (cervical spine), larger than others. Suborbital angle virtually obsolete. Brachiosteagal spine moderately strong. Entire dorsolateral and lateral surfaces of carapace studded with tubercles, some of them spiniform.

Abdomen only slightly longer than carapace (25.9 and 25.3 mm). Pleura of third through fifth abdominal segments truncate ventrally, those of fourth and fifth segments subangular caudoventrally. Cephalic section of telson with single fixed spine in caudodextral corner and 2 in caudosinistral corner. Cephalic lobe of epistome (Fig. 1*h*) sub-rhomboidal but asymmetrical with cephalomedian projection, 3 acute prominences on cephalosinistral margin, and 2 on cephalodextral; main body of epistome with shallow cephalomedian fovea continuous with caudally disposed submedian sulcus abutting epistomal zygoma. Ventral surface of proximal podomere of antennular peduncle with prominent submedian spine near midlength. Antenna with moderately large spine on basis and small spiniform tubercle on ischium; flagellum extending caudally beyond telson by at least length of latter. Antennal scale (Fig. 1*i*) almost twice as long as broad, widest distal to midlength, and lamellar (part) about twice as wide as thickened lateral part.

Third maxilliped extending anteriorly to, or slightly beyond, level of tip of rostrum; ischium with distolateral extremity produced in acute prominence, and lateral half of ventral surface with scattered short setiferous punctations; exopod reaching distal end of carpus.

Right chela (Fig. 1*n*) subovate in cross section, not strongly depressed. Mesial surface of palm with several irregular rows of 10 or 11 strongly elevated tubercles; remainder of palm also tuberculate, more mesial tubercles stronger than more lateral ones on both dorsal and ventral surfaces. Both fingers with well defined submedian longitudinal ridge flanked proximally by tubercles and more distally by setiferous punctations. Opposable margin of fixed finger with row of 8 tubercles along proximal half of finger, third from base largest, and with single, large, more ventrally situated one slightly proximal to midlength; band of minute denticles extending almost from proximal end of finger (between and ventral to row of tubercles) to base of corneous tip, band distinctly broader distal to level of ventral tubercle. Lateral surface of fixed finger with tubercles, decreasing in size dis-

TABLE 1. Measurements (mm) of *Procambarus (Ortmannicus) franzi*.

	Holotype	Allotype	Morphotype
Carapace			
Height	10.2	11.1	10.0
Width	13.1	12.9	12.2
Total length	25.3	26.9	25.2
Postorbital length	21.5	22.1	20.9
Areola			
Width	0.7	0.7	0.8
Length	10.3	10.4	10.2
Rostrum			
Width	3.6	3.6	3.5
Length	5.2	5.9	5.6
Chela			
Length of mesial margin of palm	9.0	7.0	7.0
Width of palm	5.6	4.5	4.6
Length of lateral margin	25.1	21.8	20.2
Length of dactyl	14.7	13.4	11.7
Abdomen			
Width	10.1	10.2	9.8
Length	25.9	26.7	25.3

tally, along proximal half followed by row of setiferous punctations, latter reaching base of corneous tip of finger. Opposable margin of dactyl with row of 9 tubercles, fifth from base largest, along proximal third of finger; minute denticles between and dorsal to row of tubercles and forming broad band immediately distal to last tubercle of row, band continuing to base of corneous tip of finger. Mesial surface of dactyl similar to lateral surface of fixed finger with tubercles diminishing in size distally.

Carpus of cheliped longer than broad, tuberculate on all surfaces, conspicuously so mesially where 1 tubercle more prominent than others; additional strong tubercle present on dorsomesial distal angle. Shallow oblique sulcus on dorsal surface flanked by small subsquamous tubercles. Ventrodistal margin of podomere with 3 tubercles: weak lateral one, moderately strong one on articular knob, and prominent acute one mesially; row of 3 tubercles extending proximally from latter.

Merus of cheliped strongly tuberculate except for proximal parts of mesial and lateral surfaces. Dorsal surface with linear series of tubercles basally continuous with broadening band of them distally; tubercles on ventral surface abundant, not limited to usual 2 rows; rows poorly

defined but each consisting of 20 to 23 tubercles. Ischium with row of 6 tubercles ventromesially, distalmost slightly larger than proximal 5.

Hooks on ischia of third and fourth pereiopods (Fig. 1g) as described in "Diagnosis." Coxa of fourth pereiopod with prominent oblique (almost vertical), somewhat inflated caudomesial boss; that of fifth pereiopod with very weak prominence corresponding to caudomesial boss on fourth pereiopod.

Sternum between third and fourth pereiopods rather deep with conspicuous mat of plumose setae extending mesially from ventrolateral margins. First pleopods (Fig. 1b, f, j, k, m) as described in diagnosis; mesial process of left member not bent nearly so strongly laterally as that on right pleopod. Uropod with both lobes of basal podomere bearing spines; distomedian spine on mesial ramus far removed from distal margin of ramus.

Allotypic Female: Differing from holotype in following respects: rostrum with marginal spines and reaching proximal end of ultimate podomere of antennular peduncle; subrostral ridges evident in dorsal aspect only along basal fourth of rostrum; tubercles of spiniform row flanking caudal margin of cervical groove much less conspicuous and cervical spine smaller; cephalic section of telson with 2 spines in each caudolateral corner; cephalic lobe of epistome symmetrical with weak prominences at angles of rhomboid; opposable margin of fixed finger of chela with row of 9 tubercles, fourth from base largest, that of dactyl with row of 13 tubercles, fifth from base largest; ventromesial margin of ischium of cheliped with row of 7 tubercles.

Annulus ventralis (Fig. 1d) only moderately deeply situated in sternum (see "Diagnosis" for details). Sternum immediately cephalic to annulus lacking ornamentations. First pleopod reaching slightly cephalic to caudal margin of annulus when abdomen flexed (see "Measurements").

Morphotypic Male, Form II: Differing from holotype in following respects: rostrum with small marginal tubercle dextrally (sinistral margin as in holotype), and reaching almost midlength of ultimate podomere of antennular peduncle; subrostral ridges evident in dorsal aspect from caudal margin of orbit to acumen; postorbital ridge with well defined posterior tubercles, sinistral one almost serrate; cervical spine very small, hardly larger than adjacent tubercles; epistome similar to that of allotype but anterolateral angles less sharp, and weak prominences present closely flanking cephalomedian prominence; cephalic section of telson with single fixed spine in each caudolateral corner; lateral ramus of sinistral uropod deformed, possessing bilobed distal segment; opposable margin of fixed finger of chela with row of 6 tubercles, that of dactyl with 11; ventromesial surface of ischium of cheliped with row of 8 tubercles and few others nearby; hooks on ischia of third and fourth pereiopods much reduced, that on third not overreaching basioischial articulation; boss on coxa of fourth pereiopod also much reduced. First pleopod (Fig. 1c, e) without corneous ter-

minal elements; mesial and cephalic processes much shorter and heavier, caudal element much less sharply defined, and central projection shorter, and decidedly more tumescent (see "Measurements").

Type-locality: Orange Lake Cave, 0.4 mi S of junction of U.S. Hwy. 441 and State Route 318 off Hwy. 411 (T.12S, R.21E, Sec. 33/34), Marion County, Florida.

Orange Lake Cave is a small, horizontal cavern located on the north side of a quarry of several acres. The status of the entrance prior to quarrying operations is unknown. The two present openings (2 m \times 1.5 m; 1.5 m \times 3 m) lead into a small room. The main passage (approximately 1 m wide) leads north and northeast from about 20 m and terminates in a large, irregular room (15 m long, 5 m wide, and 3–7 m high) where the water level fluctuates markedly. On 8 September 1974, water was encountered within 5 m of the entrance, and the floor of the entire passage and that of the room in the back of the cave were inundated. On 18 May 1975 and 19 November 1975, the water was about a meter lower and was confined to the rear of the big room. On other visits (5 January 1975, 28 September 1974, etc.) water levels were intermediate between these extremes. Water temperature remained at 21–22° C throughout the collecting period.

In the spring, as many as 3700 bats (*Myotis austroriparius*) use the back room of this cave as a maternity site. Throughout the remainder of the year, the bats are not usually present, but Richard Franz reported 6000 individuals having been found there on 19 November 1975. The bats are probably responsible for the major source of energy for the Orange Lake Cave crayfish population. Nearly all of the crayfish were observed in the pool directly under the bat roosts. The total number of crayfish counted on 18 May 1975 and 19 November 1975, when they were confined to one pool, was 32 and 23, respectively. A large percentage of the population consisted of juveniles.

On two occasions (October 1974 and 5 January 1975), several small, white crayfish, assumed to be a part of this same population, were seen in a small solution cavity in the floor of the quarry. The water level was about 1.5 m below the bottom of the quarry. Other openings in the sides and bottom of this same quarry apparently do not contain water.

Disposition of Types: The holotype, allotype, and morphotype are deposited in the National Museum of Natural History (Smithsonian Institution), numbers 146992, 146993 and 146994, respectively, as are the paratypes consisting of 1 ♂ II, 5 ♀, and partly decayed remains of 1 ♂ I.

Size: The largest of the specimens is a female having a carapace length of 29.0 mm (postorbital carapace length 23.5 mm). Perhaps the (partly) decayed form I male was a little larger. The only other first form male is the holotype possessing corresponding lengths of 25.3 and 21.5 mm.

Range and Specimens Examined: This crayfish is known only from

the type-locality, and the only specimens available are those included in the type-series: 1 ♂ I, 8 September 1974, R. Franz and D. S. Lee, coll.; 1 ♂ II, 2 ♀, 1 October 1974, R. F. and D. S. L., coll.; 3 ♀, 19 May 1975, B. Lee and D. S. L.; 1 ♂ I, 1 ♀, 19 November 1975, R. F., R. Bradley, and S. Scudder, coll.; 1 ♂ II, 8 December 1975, R. F. coll.

Variations: The most conspicuous variation observed is in the rostrum. Except in a few specimens in which there are marginal spines present and in the morphotype in which such a spine is present on one side, all of the other specimens lack marginal spines. Instead the rostral margins curve mesially at the base of the acumen, merging with the flattened dorsal surface of the latter. The subrostral ridges which are continuous with the margin of the acumen may be visible along the length of the rostrum from the level of the caudal margin of the orbit to the tip of the acumen, or the rostral margins may obscure, in dorsal view, part of them between the orbit and the base of the acumen. The other slight variations noted are in the number, disposition, and sizes of the tubercles, both on the carapace and on the chelipeds, but only those differences occurring on the postorbital ridges seem worthy of mention. Even in a single individual, the tubercles on the paired ridges are not identical; one ridge may have an arrangement of tubercles that might be described as almost serrate while the tubercles on the other are so reduced as to be easily overlooked. The only consistency is the presence of a small apical tubercle.

Relationships: *Procambarus (Ortmannicus) franzi* is the seventh troglotic member of the subgenus to be described, all of them from the subterranean waters of Florida, and all at least as closely related to one another as to any epigean crayfish. Three of the previously described species, *P. (O.) pallidus* (Hobbs, 1940:394), *P. (O.) horsti* and *P. (O.) orcinus* share in common a somewhat laterally displaced cephalic process on the constricted distal part of the first pleopod of the male, and the sternum immediately cephalic to the annulus ventralis in the female is produced into caudally projecting prominences that are not present in the remaining ones: *P. (O.) lucifugus lucifugus* (Hobbs, 1940:398), *P. (O.) l. alachua* (Hobbs, 1940:402), *P. (O.) erythrops*, and the species described here.

The range of *P. (O.) franzi* to the south and east of *P. (O.) l. alachua*, with which it seems to share more features than with the other species, tends to support an assumption of close kinship. Specimens that have been identified as intergrades between the two subspecies of *P. (O.) lucifugus* were obtained from several caves approximately 20 mi S of Orange Lake Cave (see Warren, 1961:7).

The characters cited above distinguish it from *P. (O.) pallidus*, *P. (O.) horsti*, and *P. (O.) orcinus*, and the absence of pigment in the eye serves readily to separate it from *P. (O.) l. alachua* and *P. (O.) erythrops*. The tapering rostrum distinguishes it from *P. (O.) l. lucifugus*, and the terminal part of the first pleopod of the male is unique.

Common Name: Because this crayfish appears to have such a limited

range, the possibility of its ultimately being placed on the list of endangered species is very real. Inasmuch as a common name will become mandatory when its status of probable safety is considered, we propose that it be known as the Orange Lake Cave Crayfish.

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PROCEEDINGS
OF THE
BIOLOGICAL SOCIETY OF WASHINGTON

NEW ENTOCYTHERID OSTRACODS FROM
KENTUCKY AND TENNESSEE

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Four new ostracods are described from crayfishes collected in the Cumberland and Tennessee River basins in Kentucky and Tennessee. One, a member of the genus *Ascetocythere*, is believed to be restricted to a burrowing crayfish, whereas the other three, assigned to the genus *Dactylocythere*, infest stream dwelling members of the genus *Cambarus* and perhaps also two species of the genus *Orconectes*. The most recent keys and summary of the genera *Ascetocythere* and *Dactylocythere* are those of Hart and Hart (1974).

Except for four lots of specimens, from three localities, which were collected by Perry C. Holt, (1 lot), Joseph F. Fitzpatrick, Jr., and H. H. Hobbs, Jr., (2), and Daniel J. Peters, Jean E. Pugh, and H. H. Hobbs, Jr. (1), all were donated to us by Raymond W. and Judith Way Bouchard who also supplied us with identifications of the hosts collected by them. We gratefully acknowledge the gift from the Bouchards and Perry C. Holt, and the assistance given to us by the other collectors. We also wish to thank Margaret A. Daniel, C. W. Hart, Jr., and Raymond B. Manning for their critical reading of the manuscript.

***Ascetocythere riopeli*, new species**

(Figure 1a-d)

Male: Eye pigmented and located between one-fourth and one-fifth shell length from anterior margin. Shell (Fig. 1a) ovate with greatest

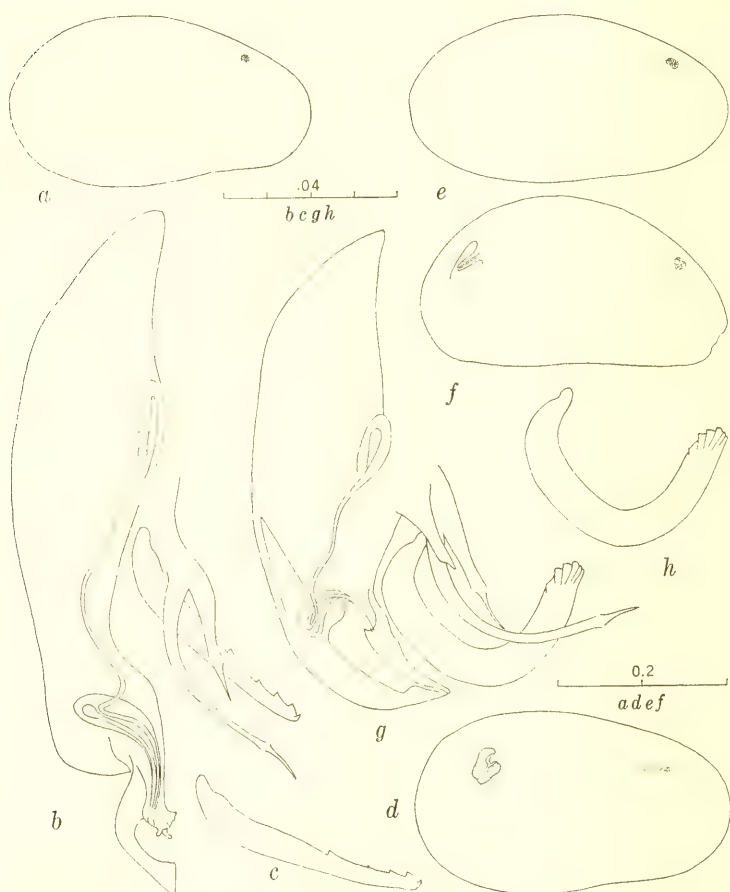


FIG. 1a-d, *Ascetocythere riopeli*, new species; 1e-h, *Dactylocythere apheles*, new species. a, e, Shell of male; b, g, Copulatory complex of male; c, h, Clasper of male; d, f, Shell of female. Scales in mm.

height one-third shell length from posterior margin where about 1.4 times height at level of eye; margin entire. Submarginal setae present except dorsally, closer together anteriorly and posteriorly than ventrally.

Copulatory complex (Fig. 1b, c) with bulbous ventral portion of peniferum bearing following processes: that borne on cephaloventral margin, and serving as conduit guiding penis, swollen distally and

flared with margin produced in several small prominences; adjacent ventrally directed process slender, subsinuous with cephaloventral extremity slightly broadened and turned laterally; vestigial caudal process situated near caudal base of sinuous process, its subacute apex directed cephalically. Penis very prominent, L-shaped, with spermatic and prostatic elements gaping for some distance at and on both sides of midlength of penis, two converging in basal part of cephaloventral process of peniferum and emerging on mesial surface of swollen distal region. Clasping apparatus only slightly curved, tapering from base, its postaxial border entire; preaxial border with 3 teeth on distal third followed by 2 apical ones. Dorsal finger moderately heavy, its setiform tip overreaching midlength of uniformly curved ventral finger, tip of which directed anteroventrally.

Triunguis Female: Eye pigmented and situated approximately one-fourth shell length from anterior margin. Shell (Fig. 1d) elongate ovate, highest about one-third shell length from posterior margin where 1.3 times height at level of eye. Submarginal setae disposed as in male but closer together anteroventrally than elsewhere. Genital complex consisting of small, weakly sclerotized prominence with concave apical margin and embedded in heterogeneous mass projecting posteroventrally from posterodorsal part of body.

Measurements (in mm): 4 males and 1 female.

	Holotype	Males	Allotype
Length (range)	0.39	0.38–0.41	0.41
Average		0.39	
Height (range)	0.22	0.22–0.24	0.22
Average		0.22	

Type-locality: Poor Fork of the Cumberland River, at Upper Cumberland School, 0.6 mi from Virginia state line, Letcher County, Kentucky. The specimens were retrieved from a collection of crayfishes containing *Cambarus* (*Jugicambarus*) *dubius* Faxon, *C. (J.) distans* Rhoades, *C. (Puncticambarus)* *robustus* Girard, and *C. (P.) buntingi* Bouchard.

Disposition of Types: The holotypic male and allotypic female are deposited in the National Museum of Natural History (Smithsonian Institution), numbers 155317 and 155318, respectively, as are the paratypes.

Range and Specimens Examined: Six specimens from two localities in Kentucky: Type-locality, 30 March 1974, R. W. and J. W. Bouchard, coll. and Marrowbone Creek at State Route 195 and Elkhorn Creek at State Route 197 (combined collection), Pike County, Kentucky, 29 March 1974, R.W.B. and J.W.B., coll.

Hosts: Although five species of crayfishes are represented from the collections containing this ostracod (*Cambarus* (*Jugicambarus*) *dubius*,

C. (J.) distans, *C. (Puncticambarus) robustus*, *C. (P.) buntingi*, and *Orconectes juvenilis* (Hagen)), it is highly probable that this ostracod is confined to *C. (J.) dubius*.

Entocytherid Associates: In the type-locality, *Ascetocythere riopeli* was found in a collection containing *Dactylocythere spinata* Hobbs and Walton (1970:860), *Dactylocythere* sp.?, and *Donnaldsoncythere donnaldsonensis* (Klie, 1931:334). In the Pike County locality, there were no associates.

Relationships: *Ascetocythere riopeli* is a member of the Asceta Group and is perhaps more closely allied to *As. sclera* Hobbs and Hart (1966: 42) than to any other member of the Group. The absence of a cephalic process on the peniferum of the male and the presence of a slender sinuous sclerotized process projecting ventrally from the bulbous area provide a unique combination of characters separating this species from its congeners.

Etymology: This ostracod is named in honor of our mutual friend, James L. Riopel, Director of the Mountain Lake Biological Station of the University of Virginia, who, for a number of years, has encouraged us in our studies of the entocytherids.

***Dactylocythere apheles*, new species**

(Figure 1e-h)

Male: Eye pigmented and located between one-fifth and one-sixth shell length from anterior margin. Shell (Fig. 1e) subovate; greatest height slightly posterior to midlength where almost 1.4 times that at level of eye; ventral margin weakly convex. Submarginal setae somewhat closer together anteriorly and posteriorly than ventrally, and absent dorsally. Sternal spine lacking.

Copulatory complex (Fig. 1g, h) with slender, distally tapering finger guard provided with anteriorly eccentric tip; peniferum moderately slender with ventral part curved anteroventrally and tapering rather rapidly to acute anteroventral angle; ventral part of tip corneous. Peniferal groove opening anteroventrally, almost closed in apical region, its least diameter approximately one-tenth that of corresponding diameter of vertical ramus of clasping apparatus. Penis L-shaped with arms subequal in length. Accessory groove represented by short triangular clear area posterodorsal to base of penis, its apex barely or not reaching level of spermatic loop. Clasping apparatus C-shaped with short proximal area subparallel to longer distal segment (horizontal ramus); apparatus of almost uniform diameter throughout and with margins entire; distal part with distally radiating grooves extending toward 5 or 6 apical denticles. Dorsal and ventral fingers comparatively slender, latter about twice length of former and gently curved with distal half directed anteriorly.

Triunguis Female: Eye pigmented, situated as in male. Shell (Fig. 1f) strongly arched dorsally and with almost straight ventral margin;

greatest height slightly posterior to midlength where about 1.5 times that at level of eye. Submarginal setae disposed as in male. Posterior margin of shell entire, smoothly rounded. Genital complex consisting of weakly sclerotized, slender, tubular papilla directed posteroventrally; usual J-shaped rod and amiculum lacking.

Measurements (in mm): 3 males and 4 females.

	Holotype	Males	Allotype	Females
Length (range)	0.41	0.40–0.41	0.39	0.36–0.39
Average		0.40		0.38
Height (range)	0.22	0.21–0.22	0.21	0.21–0.22
Average		0.22		0.21

Type-locality: Spring seep flowing across old road to Chimneys at Indian Gap (Little Pigeon River drainage), Sevier County, Tennessee. There the type-series was collected with *Uncinocythere zanca* Hobbs and Walton (1963:456) on 13 November 1971, by R. W. Bouchard and J. D. Way.

Disposition of Types: The holotypic male and allotypic female are deposited in the National Museum of Natural History (Smithsonian Institution), numbers 155319 and 155320, respectively. Paratypes are in the collection of H. H. Hobbs III and the Smithsonian Institution.

Range and Specimens Examined: Seven specimens collected at the type-locality (Little Pigeon River basin).

Host: *Cambarus* (J.) *carolinus* (Erichson).

Entocytherid Associate: *Uncinocythere zanca*.

Relationships: *Dactylocythere apheles* has its closest affinities with *Dactylocythere leptophylax* (Crawford, 1961:238). The male of both species possesses a peniferum with a reduced accessory groove, at least occasionally hardly discernible; the margins of the clasping apparatus are entire, and the distal extremity bears at least 4 denticles set off proximally by distally diverging striae. The females of both species lack the usual J-shaped rod and amiculum. Members of the new species differ from those of *Dt. leptophylax* in possessing a simple as opposed to a distally bifid or trifid finger guard; the ventral extremity of the peniferum is smooth, lacking tuberculiform prominences, and the distal part of the clasping apparatus is not expanded.

Etymology: *Apheles*, G. = smooth; referring to the absence of teeth or prominences on the preaxial border of the clasping apparatus and on the ventral margin of the peniferum of the copulatory complex of the male.

***Dactylocythere brachydactylus*, new species**
(Figure 2a–d)

Male: Eye pigmented and situated about one-fifth shell length from anterior margin. Shell (Fig. 2c) subovate with greatest height about

one-third shell length from posterior margin where approximately 1.3 times height at level of eye; ventral margin straight to weakly convex. Submarginal setae present around entire shell, slightly closer together anteriorly and posteriorly than dorsally or ventrally; other setae widely scattered over surface of shell. Sternal spine lacking.

Copulatory complex (Fig. 2*b, d*) with short, robust finger guard produced in bifurcate extension from cephaloventral side and with posterior angle at level of base of extension; peniferum comparatively heavy with ventral portion subtruncate and apical part directed antero-ventrally. Peniferal groove conspicuous, its least diameter from one- to three-fourths as wide as least diameter of vertical ramus of clasping apparatus. Penis L-shaped with rami subequal in length. Accessory groove slender and long, reaching dorsally distinctly beyond level of dorsal extremity of spermatic loop. Clasping apparatus more L- than C-shaped, rami indistinctly delimited; postaxial margin of vertical ramus with slight angle near midlength, and preaxial margin of horizontal ramus with 1 or 2 minute teeth near 3 terminal denticles and marked by oblique striae extending proximally from teeth; remaining borders of apparatus entire. Dorsal and ventral fingers slender, former about one-half length of gently and evenly curved ventral finger, latter directed anteriorly.

Triunguis Female: Eye pigmented, situated between one-fifth and one-sixth shell length from anterior margin. Shell (Fig. 2*a*) much more highly vaulted than in male, highest about one-third shell length from posterior margin where approximately 1.5 times height at level of eye; ventral margin slightly concave near midlength. Disposition of setae on shell similar to that on male. Posterior margin of shell entire and rounded. Genital complex consisting of slender, non-corneous tubular prominence, directed posteroventrally, flanked posterodorsally by similarly directed inflated sclerotized projection capped by hyalin coat and with heterogeneous material adhering to antero-ventral margin; usual J-shaped rod and amiculum lacking.

Measurements (in mm): 10 males and 10 females.

	Holotype	Males	Allotype	Females
Length (range)	0.47	0.44-0.47	0.49	0.47-0.49
Average		0.46		0.48
Height (range)	0.27	0.25-0.27	0.29	0.27-0.29
Average		0.25		0.29

Type-locality: Goose Creek at State Route 66 southwest of Dandridge, Jefferson County, Tennessee. There the host was *Cambarus* (C.) *bartonii* (Fabricius); specimens of *Orconectes virilis* (Hagen) were also collected in this locality and may have been infested with

this ostracod. No other ostracod was infesting the host. Collections were made there on 16 March 1969 by R. W. Bouchard.

Disposition of Types: The holotypic male and allotypic female are deposited in the National Museum of Natural History (Smithsonian Institution), numbers 155321 and 155322, respectively. Paratypes are in the collections of H. H. Hobbs III, D. J. Peters, and the Smithsonian Institution.

Range and Localities: Little Tennessee, French Broad, Nolichucky, and Tennessee river basins in Cocke, Jefferson, and Roane counties, Tennessee.

TENNESSEE: *Cocke County*—(1) Jake Best Creek on road S from Citico Creek, SE of Acorn (Host, *Cambarus* (C.) *bartonii* (Fabricius)). *Jefferson County*—(2) Type-locality; (3) Long Creek at State Rte. 32 and U.S. Hwy. 25 E, N of White Pine (Host, *Cambarus* (*Hiaticambarus*) *longirostris* Faxon); (4) Spring Creek on U.S. Hwy. 70 W of junction with State Rte. 113 near Oak Grove (Host, *Cambarus* (C.) *bartonii*); (5) Embayment of Spring Creek off U.S. Hwy. 70 and State Rte. 9, near Douglas Lake (Hosts, *Cambarus* (C.) *bartonii*, *Orconectes virilis* (Hagen), *Orconectes forceps* (Faxon)). *Roane County*—(6) Caney Creek at Buttermilk Road, off I-40 SE of Bradbury (Hosts, C. (C.) *bartonii*, C. (H.) *longirostris*). Collections from localities 1-4 were made by R. W. Bouchard, that from 5 by D. A. Etnier, and that from 6 by Bryant.

Hosts: Although this ostracod was found in collections of crayfishes containing *Cambarus* (C.) *bartonii*, C. (H.) *longirostris*, *Orconectes forceps*, and *O. virilis*, it is probable that it is actually associated with only the former two.

Entocytherid Associates: In the Cocke County locality it was associated with *Donnaldsoncythere donnaldsonensis* (Klie, 1931:334); in the Long Creek locality in Jefferson County, it was found with *Uncinocythere simondsi* (Hobbs and Walton, 1960:17); and in the Roane County locality, with *Dactylocythere falcata* (Hobbs and Walton, 1961:379).

Relationships: *Dactylocythere brachydactylus* has its closest affinity with *Dt. chelomata* (Crawford, 1961:242). The similarities in the genitalia of the males are striking; however, members of the former possess a much longer accessory groove in the peniferum, one approaching the length of that in *Dt. mecoscapha* (Hobbs and Walton, 1960:19) and *Dt. macroholca* Hobbs and Hobbs (1970:6). In addition, the denticles along the distal preaxial border of the horizontal ramus of the clasping apparatus are not nearly so well-developed. The females of the two species may be distinguished by the absence of a J-shaped rod and amiculum in the genital complex of *Dt. brachydactylus*.

Etymology: Brachys G. = short + Dactylus, G. = finger; referring to the comparatively short finger guard on the copulatory complex of the male.

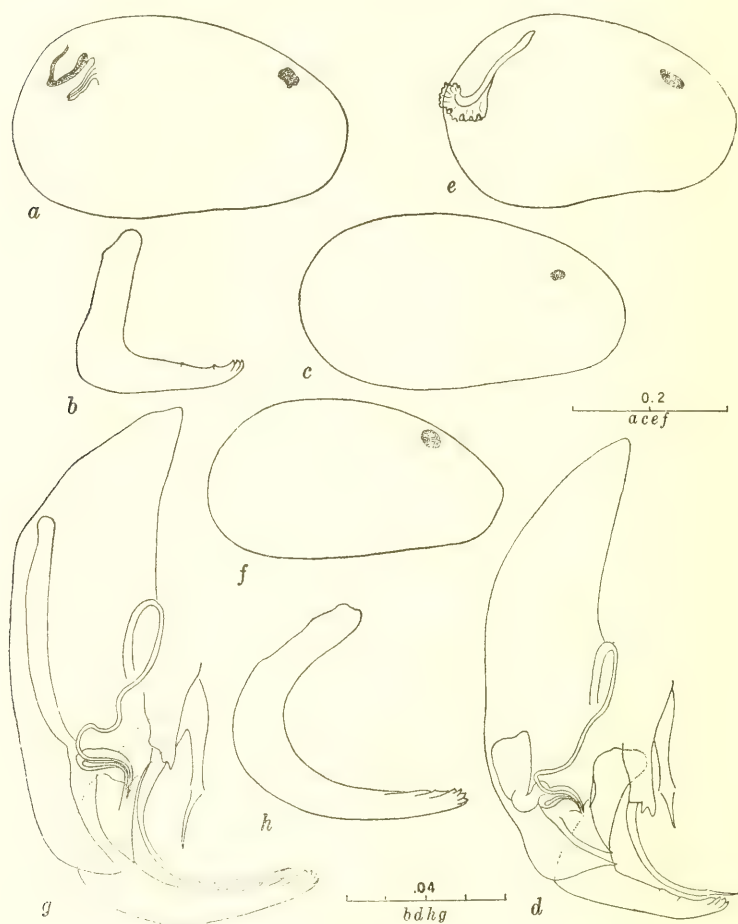


FIG. 2a-d, *Dactylocythere brachydactylus*, new species; 2e-h, *Dactylocythere demissa*, new species. a, e, Shell of female; b, h, Clasper apparatus of male; c, f, Shell of male; d, g, Copulatory complex of male. Scales in mm.

***Dactylocythere demissa*, new species**
(Figure 2e-h)

Male: Eye pigmented and situated about one-fourth shell length from anterior margin of shell. Shell (Fig. 2f) elongate ovate (about 1.8 times as long as high) with greatest height about one-third shell length from posterior margin where about 1.3 times height at level

of eye; ventral margin almost straight. Submarginal setae present except dorsally, closer together anteriorly and posteriorly than ventrally. Sternal spine absent.

Copulatory complex (Fig. 2g, h) with robust finger guard produced in bifurcate extension from cephaloventral side and with posterior angle at level of base of extension; peniferum comparatively stout with ventral portion truncate, anteroventral angle acute and directed anteriorly. Peniferal groove distinct, rather uniformly narrow with least diameter about one-fifth that of least diameter of vertical ramus of clasping apparatus. Penis somewhat L-shaped with distal ramus hardly more than half length of proximal ramus. Accessory groove short, not nearly reaching ventral extremity of spermatic loop, with end adjacent to penis forming inverted (ventrally directed) loop—unique in the genus in this respect. Clasping apparatus L-shaped with postaxial border distinctly angular at junction of horizontal and vertical rami; vertical ramus with postaxial border concave but otherwise entire, its preaxial border almost straight to broadly but shallowly concave; horizontal ramus with postaxial border entire, its preaxial border with 2 small teeth on distal half, and apex of ramus with 3 anterodorsally directed denticles. Dorsal finger comparatively heavier than very slender ventral finger and almost one-half as long; latter gently curved throughout most of its length and with distal portion directed anteriorly.

Triunguis Female: Eye as in male. Shell (Fig. 2e) distinctly more highly vaulted than in male (about 1.5 times as long as high) with greatest height approximately one-third shell length from posterior margin where about 1.3 times height at level of eye; ventral margin slightly concave anterior to midlength. Disposition of submarginal setae on shell similar to that on male but also with widely spaced ones dorsally. Posterior margin of shell often with eccentric prominence in vicinity of amiculum. Genital complex consisting of J-shaped rod with long vertical arm inclined subparallel to posterodorsal margin of shell and with conspicuous but short amiculum borne on curved portion of rod; amiculum with short supportive hyaline arcs and often slightly protruding from between caudal margin of valves of shell.

Measurements (in mm): 10 males and 10 females.

	Holotype	Males	Allotype	Females
Length (range)	0.42	0.40–0.43	0.42	0.40–0.43
Average		0.41		0.42
Height (range)	0.22	0.21–0.24	0.25	0.23–0.26
Average		0.23		0.25

Type-locality: Pokepatch Creek at County Road 4385, southwest of Pleasant Hill, Cumberland County, Tennessee (Caney Fork River drainage). Specimens were obtained from a collection of crayfishes (containing *Cambarus* (*Veticambarus*) *pristinus* Hobbs, *Cambarus* (*Jugicambarus*) *parvovulus* Hobbs and Shoup, and *Cambarus* (*De-*

pressicambarus) *sphenoides* Hobbs) made by R. W. Bouchard on 7 August 1969.

Disposition of Types: The holotypic male and allotypic female are deposited in the National Museum of Natural History (Smithsonian Institution) number 155323. Paratypes are in the collection of H. H. Hobbs III, J. D. Peters, and the Smithsonian Institution.

Range and Localities: Caney Fork and Obey (Cumberland River), Emory, and Tennessee river basins on the Cumberland Plateau.

TENNESSEE: *Bledsoe County*—(1) McGill Creek at County Rd. 5881 S of Brayton (Hosts, *C. (D.) sphenoides* Hobbs, *C. (J.) parvocolus* Hobbs and Shoup); (2) Roaring Creek off County Rd. 5881, SW of New Harmony (Hosts, *C. (D.) sphenoides*, *C. (J.) parvocolus*); (3) Henderson Creek at County Rd. 5881 NE of Summer City (Hosts, *C. (D.) sphenoides*, *C. (J.) parvocolus*); (4) Moccasin Creek at County Rd. 5881 SW of Milo (Host, *C. (J.) parvocolus*); (5) Glade Creek at State Rte. 30, NW of Pikeville (Host, *C. (J.) parvocolus*). *Cumberland County*—(6) Type-locality; (7) Caney Fork River at U.S. Hwy. 70 (Hosts, *C. (D.) sphenoides*, *C. (V.) pristinus* Hobbs); (8) Clear Creek at County Rd. 4794, 3 mi W of junction with U.S. Hwy. 127 (Host, *C. (J.) crinipes* Bouchard); (9) No Business Creek at U.S. Hwy. 127, N of Isoline (Hosts, *C. (D.) sphenoides*, *C. (J.) distans* Rhoades); (10) Little Obed River at U.S. Hwy. 127, N city limits of Crossville (Hosts, *C. (D.) sphenoides*, *C. (J.) distans*, *C. (J.) parvocolus*); (11) Daddy's Creek at U.S. Hwy. 127 near Big Lick (Host, *C. (J.) distans*); (12) White Oak Creek, 3.9 mi E of White County line and 0.1 mi S of U.S. Hwy. 70 (Hosts, *C. (D.) sphenoides*, *C. (V.) pristinus*); (13) Fox Creek off County Rd. 4252 (Catoosa Wildlife Management Area) (Hosts, *C. (J.) distans* Rhoades, *C. (J.) parvocolus*); (14) South Fork of Elmore Creek at County Rd. 4252 (Hosts, *C. (D.) sphenoides*, *C. (J.) distans*, *C. (J.) parvocolus*); (15) Caney Fork River at County Rd. between U.S. Hwy. 70 and 70N, NE of Pleasant Hill (Hosts, *C. (D.) sphenoides*, *C. (J.) parvocolus*, *C. (V.) pristinus*). *Grundy County*—(16) Firescald Creek at County Rd. 4398, in Altamont (Hosts, *C. (D.) sphenoides*); (17) Piney Creek at State Rte. 108, at Altamont (Host, *C. (D.) sphenoides*). *Putnam County*—(18) Dripping Springs Creek at State Rte. 62, SE of Monterey (Hosts, *C. (D.) sphenoides*, *C. (J.) obeyensis*). *Rhea County*—(19) Whites Creek at State Rte. 68, NW of Grand View (Hosts, *C. (D.) sphenoides*, *C. (J.) parvocolus*). *White County*—(20) Pole Bridge Branch at County Rd. 4385, S of DeRossett (Hosts, *C. (D.) sphenoides*, *C. (J.) parvocolus*). All of the specimens from the above localities, except stations 8, 12, and part of those from 6 were collected by R. W. Bouchard or R.W.B. and J. D. Way.

Hosts: As may be noted above, in most of the localities this ostracod was associated with *Cambarus (D.) sphenoides*, frequently with *C. (J.) parvocolus*, also with *C. (V.) pristinus* in the Caney Fork drainage, and occasionally with *C. (J.) distans*.

Entocytherid Associates: The entocytherids most frequently sharing the hosts with *Dactylocythere demissa* are *Donnaldsoncythere donnaldsonensis*, and *Dactylocythere brachystrix* Hobbs and Walton (1966:2). Occasionally accompanying it are *Dt. pachysphyrata* Hobbs and Walton (1966:3), *Dt. speira* Hart and Hart (1971:113), and *Entocythere* sp. In one locality each, it was found in association with *Dt. arcuata* (Hart and Hobbs, 1961:173) and *Dt. spinata* Hobbs and Walton (1970:853).

Relationships: One of the most distinctive features of this ostracod is the very short accessory groove of the peniferum, which, in its length, is similar to that in *Dactylocythere coloholca* Hobbs and Hobbs (1970:7), *Dt. exoura* Hart and Hart (1966:5), and *Dt. speira*. In other respects, it also has as much in common with these species as with any of its congeners. In none of the three, however, is the finger guard of the copulatory complex produced in a bifid tip. While *Dt. demissa* appears to be more closely allied to *Dt. speira* than to the other two in possessing a similar clasping apparatus and a rather broad accessory groove, the peniferum of the former is truncate ventrally, the accessory groove is disposed in a distinct ventral loop, and the J-shaped rod of the genital complex of the female has an almost straight shaft with a gently curved ventral part rather than being strongly curved throughout, almost forming a spiral. In addition, *Dt. demissa* possesses a distinct amiculum that is lacking in *Dt. speira*.

Etymology: *Demissus*, *L.* = hanging down; so named because of the long, almost straight J-shaped rod in the genital complex of the female; also the looped ventral part of the accessory groove in the peniferum of the male suggests a collapse of the groove.

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12 October 1976

PROCEEDINGS
OF THE
BIOLOGICAL SOCIETY OF WASHINGTON

TWO NEW SEA CUCUMBERS (ECHINODERMATA:
HOLOTHUROIDEA) FROM THE EASTERN
UNITED STATES

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During the examination of holothurians collected by the Northeast Center, National Marine Fisheries Service, Woods Hole, Massachusetts, two new species were found; they are described here. Both species will be discussed further in a report on distribution patterns of holothurians off the eastern United States (Wigley and Pawson, in prep.).

I am grateful to Dr. Roland L. Wigley, National Marine Fisheries Service, for giving me access to the collections in his care, and for his help in many other ways. Type-material is deposited in the National Museum of Natural History, Smithsonian Institution.

Order APODIDA

CHIRIDOTIDAE

Chiridota Eschscholtz, 1829

Chiridota wigleyi, new species

Figure 1F-H

Diagnosis: Wheel papillae very scarce, apparently restricted to dorsal interradial. Radial and interradial areas of body wall with numerous curved rods with bifurcated ends; rods average 63 μm in length. Tentacles with curved rods with branching ends; tentacle rods average 85 μm in length.

Material examined: Holotype (USNM E15904, 40 mm total length) DELAWARE cruise 62-7, station 24, 15 June 1962, 40°20'N, 70°15'W, 90 m, silty sand, bottom temperature 7.8° C. Paratypes 20 specimens (USNM E15905, 25-114 mm total length) same locality data as holotype.

The species was collected at 20 stations off the eastern United States, in an area bordered by latitudes 39°47'N and 40°30'N and longitudes 69°31'W and 71°46'W; bathymetric range 70–301 m; bottom temperature 6.6–11.6° C; bottom type sand to sandy silt to sand-silt-clay.

Etymology: The species is named for Dr. Roland L. Wigley, in recognition of his many contributions to our knowledge of the marine fauna of the northwestern Atlantic.

Description: Total length 25–114 mm. All specimens contracted to varying degrees, cylindrical, dark reddish-brown in alcohol. Tentacles 12 with 5–7 pairs of digits. Ossicles in body wall include wheels and curved rods. Wheels aggregated loosely into poorly defined papillae which are sparsely scattered in dorsal interradii. In one specimen of 100 mm total length only 4 wheel papillae present, containing 28, 40, 18 and 17 typical chiritodid wheels averaging 86 μ m in diameter. Curved rods with bifurcated ends (Fig. 1H) scattered in radial and interradiial areas of body wall. Average length of rods 63 μ m (range 50–80 μ m; standard deviation 3.73). Radial longitudinal muscles contain numerous elongate miliary granules which vary greatly in length up to a maximum of approximately 100 μ m. Granules approximately cylindrical, often slightly thickened near center (Fig. 1F). Tentacle stems and digits contain rods (Fig. 1G) resembling those of body wall, but with more complex terminal branches and greater variation in size. Average length of tentacle rods 85 μ m (range 55–115 μ m; standard deviation 8.7).

Remarks: In possessing numerous rods in the body wall, this new species is immediately distinguished from other temperate North Atlantic and Arctic species *Chiridota laevis* (Fabricius), *C. pellucida* (Vahl), *C. spirourna* Heding, *C. groenlandica* Heding and *C. abyssicola* von Marenzeller, all of which lack such rods (Heding 1928, 1935). The only other known North Atlantic species, *C. rotifera* (Pourtales), has smaller rods in the body wall (length averaging 30 μ m), and also has very numerous wheel papillae scattered in all radii. *C. rotifera* is tropical, occurring in shallow water in Bermuda and the West Indies (Clark, 1933).

Order DENDROCHIROTIDA

CUCUMARIIDAE

Ocnus Forbes, 1841

Ocnus diemedae, new species

Figure 1A–E

Diagnosis: Ossicles in body wall rudimentary cups comprising a primary cross with projecting knobs and averaging 41 μ m in length, overlying knobbed plates of one type which are highly variable in shape and size; average length of plates 72 μ m. Tube feet contain elongate smooth or knobbed plates.

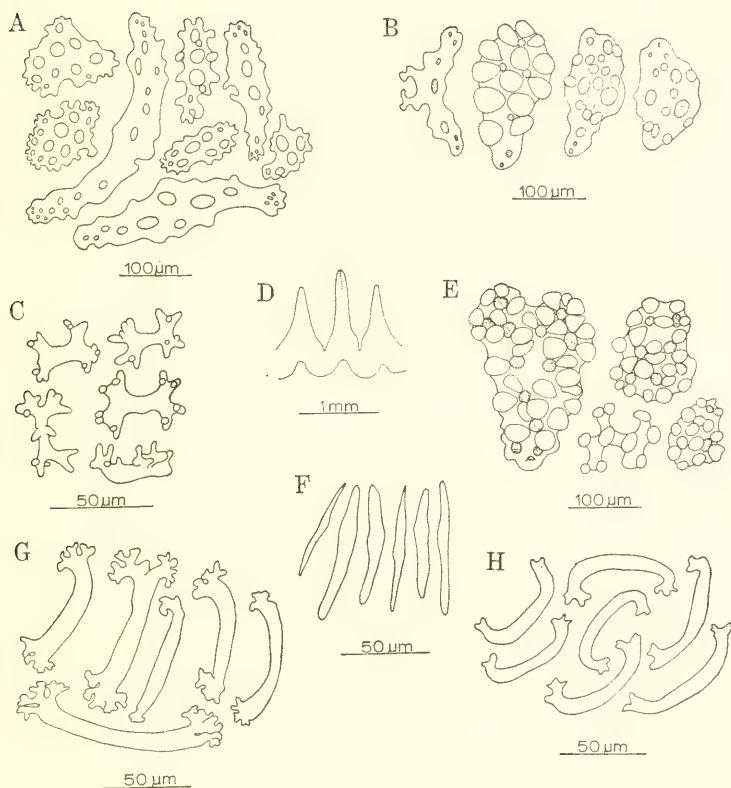


FIG. 1A-E. *Ocnus diomedea* n. sp. A, Plates from tentacles; B, Ossicles from tube feet; C, Cups from body wall; D, One radial piece and two interradials from calcareous ring; E, Plates from body wall. F-H, *Chiridota wigleyi* n. sp. F, Miliary granules from radial muscles; G, Rods from tentacles; H, Rods from body wall.

Material examined: Holotype (USNM E15906, 15 mm total length) ALBATROSS IV cruise 66-9, station 1004, 15 July 1966, 42°11'N, 65°50'W, 247 m, gravel. Paratypes: 19 specimens (USNM E15907, 8-17 mm total length) same locality data as holotype; 5 specimens (USNM E15908, 9-19 mm total length) ALBATROSS IV cruise 66-9, station 1005, 16 July 1966, 42°13'N, 65°42'W, 229 m, gravel; 12 specimens (USNM E15909, 10-17 mm total length) ALBATROSS IV cruise 68-12, station 72, 15 August 1968, 42°22'N, 65°55'W, 192 m, gravel.

Etymology: Species named for collecting vessel. *Diomedea* is generic name for the albatross.

Description: Body 2–3 times as long as broad, mouth and anus terminal. Total length 8–19 mm. Body wall thin, stiff, packed with ossicles. Tube feet restricted to radii, in 5 more or less double rows. One or 2 feet may be present in mid-dorsal interradius. Tube feet apparently only partly retractile. Tentacles 10, richly branched; ventral pair of tentacles smaller than others. Body and tube feet light orange to white in alcohol; tentacles light yellow.

Calcareous ring simple (Fig. 1D) with undulating posterior margin. Retractor muscles attach to radial muscles at about middle of body. Polian vesicle single. Respiratory trees well developed, extending to anterior of body cavity. Gonad a tuft of several caeca at about mid-body. In females caeca contain yolky eggs approximately 700 μ m in diameter.

Ossicles in body wall knobbed plates and rudimentary cups. Plates (Fig. 1E) highly variable in shape and size, averaging 72 μ m in length (range 120–300 μ m; standard deviation 14.64). Basic plate apparently 4-holed, but very few 4-holed examples seen. Cups (Fig. 1C) minute, averaging 41 μ m in length (range 38–44 μ m; standard deviation 1.81), comprising central rod with terminal bifurcation (primary cross pattern), each furca carrying small knobs.

Tube feet with rudimentary end plates; walls of feet contain numerous elongate smooth or knobbed plates (Fig. 1B) which are highly variable in shape and size. Tentacles packed with curved perforated rods and small perforated plates (Fig. 1A); plates and rods usually smooth, or with few small knobs.

Remarks: Rowe (1970) erected the new genera *Aslia* and *Pawsonia* to accommodate some species which had originally been referred by Panning (1949) to *Ludwigia* (see Pawson, 1963). Rowe concluded also that some of the species which had originally been assembled under the preoccupied genus-name *Ludwigia* should provisionally be referred to *Ocnus*. These species included *planci* (Brandt), *lactea* (Forbes), *glacialis* (Ljungman), *hedingi* (Panning) and some others, and it is with this group of species, and therefore with the genus *Ocnus*, that *O. diomedae* appears to have its strongest relationships. In possessing rudimentary cups, *O. diomedae* is immediately distinguished from most *Ocnus*-species. *O. hedingi* (Panning), *O. syracusanus* (Grube) and *O. glacialis* (Ljungman) have similarly reduced cups, but in these species the knobbed plates in the body wall are either more complex or are of a different type, and the ossicles in the tube feet are distinctly different.

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PROCEEDINGS
OF THE
BIOLOGICAL SOCIETY OF WASHINGTONA RECLASSIFICATION OF *IRIS* SPECIES BEARING
ARILLATE SEEDS

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In his revision of the genus *Iris* L., Rodionenko (1961) placed in the subgenus *Iris* only those species with aggregations of multicellular hairs (beards) on the outer perianth segments. Beardless rhizomatous and nonrhizomatous species were placed in other subgenera, or were transferred to genera other than *Iris*. In his system, subgenus *Iris* consisted of section *Hexapogon* emended to include all species with arillate seeds, and section *Iris* containing the remaining non-arillate species. *Hexapogon* consisted of the subsections *Regelia*, *Pseudoregelia* and *Oncocyclus*. *Regelia*, however, had the same circumscription as subsection *Hexapogon* (Bunge) Benth. *emend.* Lawrence (1953), and Rodionenko's use of the name *Regelia* was superfluous (see also under section *Hexapogon* below).

Data published since the Rodionenko revision of the genus make even more obvious the heterogeneous nature of subsection *Hexapogon* (Bunge) Benth. *emend.* Lawrence and its synonym *Regelia* (Dykes) Rodionenko. The following new system for the arillate species in *Hexapogon* is proposed.

Iris subgenus *Iris*

Section *Iris* (This type section of the subgenus lacks arillate species.)

Section *Hexapogon* (Bunge) Baker

Section *Regelia* Lynch

Section *Oncocyclus* (Siemssen) Baker

Section *Psammiris* (Spach) J. Taylor

Section *Pseudoregelia* Dykes

The essential features of this reclassification are (1) the segregation of species previously included in section *Hexapogon* (Bunge) Baker *emend.* Rodionenko (1961) into five distinct taxa, and (2) the designation of a type of the section *Regelia* Lynch. A compendium of literature relevant to section *Iris* is also included.

Iris subgenus *Iris*

Iris sect. *Pogiris* Tausch in Hort. Canalius, 1 (1823); *idem* in Schultes Additamentum Mantissum, 2:369 (1824), *quoad typus*.—*Iris* subgen. *Euiris* Alefeld in Bot. Zeit., 21:296 (1863), *p.p.*; *non* Boissier Fl. Orient., 5:118 (1884); *non* Klatt in Linnaea, 33:591–604 (1866).—*Iris* sect. *Euiris* Benth in Benth and Hooker, Gen. Pl., 3:687 (1882).—*Iris* sect. *Pogiris* Tausch *emend.* Lawrence in Gent. Herb., 8(4):353 (1953).—*Iris* sect. *Iris* *emend.* Lawrence in Gard. Irises, 142 (1959).

Type of the subgenus: *I. germanica* L.

Species composing subgenus *Iris* are characterized by distinctly rhizomatous stems, and flowers with beards of multicellular hairs on the outer, and occasionally the inner, perianth segments.

KEY TO THE SECTIONS OF SUBGENUS *IRIS*

1. Seed without an aril; capsule usually dehiscent very near apex, but if dehiscent considerably below apex, then some internal placentation ruptured at maturity Section *Iris*
1. Seed with conspicuous creamy-white aril; capsule dehiscent subapically or laterally; mature placentation intact 2
2. Both inner and outer perianth segments with conspicuous more or less linear beards 3
3. Spathe valves (bracts) 3 or 4; rhizome usually compact, slowly creeping; seed with small aril; chromosome number of counted species: $n = 9$ Section *Hexapogon*
3. Spathe valves 2; rhizome stoloniferous, readily spreading; seed with large aril; chromosome number of counted species $n = 11$ Section *Regelia*
2. Only outer perianth segments bearded, or if all segments bearded, then beards on outer segments scattered 4
4. Beard on outer segments scattered; spathe 1-flowered; seed with large aril Section *Oncocyclus*
4. Beard on outer segments linear; spathe usually 2-flowered; seed with aril much smaller than seed 5
5. Rhizome creeping or spreading by stolons; flowers essentially monochromic though sometimes lightly veined Section *Psammiris*

5. Rhizome compact, gnarled; flowers usually dichromic, spotted
 ----- Section *Pseudoregelia*

Iris section *Iris*

Iris subgen. *Pogiris* Tausch, *l.c.*; *idem* in Schultes, *l.c.*—*Iris* subgen. *Pogoniris* Spach in Ann. Sci. Nat. ser. 3, 5:103 (1846); *idem* in Hist. Nat. Veg., 13:48–68 (1846), *p.p.*; Klatt in Bot. Zeit., 30:515 (1872), *p.p.*; Baker in Journ. Linn. Soc. Lon. Bot., 16:143 (1877), *p.p.*; Randolph in Bull. Amer. Iris Soc., 109:4 (1948), *p.p.*—*Iris* subgen. *Euiris* Alefeld in Bot. Zeit., 21:296 (1863), *p.p.*; *non* Boissier, *l.c.*; *non* Klatt, *l.c.*—*Iris* subsect. *Pogoniris* (Spach) Benth in Benth and Hooker, *l.c.*; Pax in Engler and Prantl, Nat. Pflanzenfam., 2(5):145 (1888), *p.p.*; Lawrence, *l.c.*—*Iris* sect. *Pogoniris* Baker, *l.c.*, *p.p.*—*Iris* subgen. *Eupogoniris* Randolph, *l.c.*

Type of the section: *I. germanica* L.

In his reclassification of *Iris*, Lawrence (1953, 1959) divided subsection *Pogoniris* into the series *Pumilae* and *Elatae*. To the former were assigned those species which are less than 3 dm tall, and either acaulescent or if caulescent, then not branched. Series *Elatae* comprised the taller species which are distinctly caulescent and branched. Although he cited these taxa, Rodionenko did not include them in his system.

Recent collections of bearded irises have included forms which could justify emending series *Pumilae* to include the low-growing species which are nevertheless caulescent and branched, e.g., *I. furcata* MB, *I. timofejewii* Woron., and perhaps others. Anyone systematically treating these non-arillate species should include such emendation if the taxon is retained.

Because of the numerous morphological, karyological, genetic and distributional differences between the arillate and the non-arillate species, Rodionenko (1961) removed arillate species from section *Iris*, based on *I. germanica* L., and gave them sectional rank collectively in *Hexapogon*. His circumscription of section *Iris* is retained here.

Iris section *Hexapogon* (Bunge) Baker in Gard. Chron. ser. 3, 5:787–788 (1876); Boissier, Fl. Orient., 5:119 (1884).

Iris subgen. *Hexapogon* Bunge *ex* Alefeld in Bot. Zeit., 21:296 (1863), *nom. illegit.*; Baker in Journ. Linn. Soc. Lon. Bot., 16:147 (1877), *nom. illegit.*—*Iris* subsect. *Hexapogon* (Bunge) Benth in Benth and Hooker, Gen. Pl., 3:687 (1882); Pax in Engler and Prantl, Nat. Pflanzenfam., 2(5):145 (1888).

Type of the section: *I. falcifolia* Bunge.

Species included within the section:

I. falcifolia Bunge 1847

I. longiscapa Ledebour 1853

The name *Hexapogon*, first used by Bunge (1847) in describing the new species *I. falcifolia* and *I. filifolia* Bunge (an invalid synonym of *I. longiscapa* Ledeb.), was taken up by Alefeld (1863) for a subgenus circumscribing the two Bunge species and *I. susiana* L. Because *I. susiana* was the type for Spach's earlier subgenus *Susiana* (1846), Alefeld's use of *Hexapogon* was illegitimate (Article 63, International Code of Botanical Nomenclature (ICBN), 1969). Baker (1876) transferred *I. susiana* to section *Oncocyclus* and first validly published *Hexapogon* as a section comprising *I. falcifolia* and *I. filifolia* Bunge only. (The following year (1877) he raised *Hexapogon* to the rank of subgenus, but his use of the name at that rank was illegitimate (Article 64, ICBN).)

In 1892, Baker transferred the *Hexapogon* species to subgenus *Pogoniris*, and introduced the name *Regelia* for a subgenus containing three species described by Eduard Regel. Although it is apparent that Baker intended to segregate *Regelia* from *Hexapogon* and *Pogoniris*, he did not adequately characterize *Regelia*, and it remained a *nomen nudum* until validly published as a section by Lynch in 1904. A type was not designated.

Dykes considered *I. falcifolia* and *I. filifolia* Bunge to be synonymous, and transferred them (1913) from *Pogoniris* to section *Regelia*. Because one or the other of these *Hexapogon* species must be considered the type for the earlier section *Hexapogon* (Bunge) Baker, Dykes' use of the name *Regelia* was illegitimate (Article 63, ICBN). Rodionenko's use of *Regelia* for a subsection (1961) was illegitimate for the same reason. Lawrence did not acknowledge section *Regelia* Lynch, and combined *Regelia* Dykes, including *Hexapogon*, with *Psammiris* species in subsection *Hexapogon* (1953, 1959).

I. falcifolia and *I. longiscapa* are xeritic species of the Turkmenian and Uzbekian deserts in southcentral U.S.S.R., and of a few similar but restricted localities in Iran and Afghanistan. They are characterized by weakly or non-stoloniferous rhizomes, very narrow leaves, thin and leafless stems, and spathes of 3 or 4 bracts enclosing 2 to 5 small flowers with all perianth segments bearded. *Iris longiscapa* has been examined karyologically (Randolph and Mitra, 1961), and is the only bearded iris species yet counted with the diploid chromosome number 18.

Iris section *Regelia* Lynch, Bk. *Iris*, 56 (1904); Fedtschenko in Komarov, Fl. USSR, 4:539 (1935); *nec* Dykes, Gen. *Iris*, 123 (1913), *p.p.*, *nom. illegit.*

Iris subgen. *Regelia* M. Foster ex Baker, Handbk. *Irideae*, 1 (1892), *p.p.*, *nom. nudum*.—*Iris* subgen. *Pogoniris* Randolph in Bull. Amer. Iris Soc., 109:4 (1948), *p.p. affin. sect. Regelia* Lynch; *non* Spach (1846), *l.c.*; *non* Baker (1876), *l.c.*—*Iris* subsect. *Regelia* (Dykes) Rodionenko, Gen. *Iris* L., 198–199 (1961), *p.p.*, *nom. illegit.*

Type of the section: *I. korolkowii* Regel.

Species included within the section:

- I. afghanica* Wendelbo 1972
- I. darwasica* Regel 1884
- I. heweri* Grey-Wilson & Mathew 1974
- I. hoogiana* Dykes 1916
- I. korolkowii* Regel 1873
- I. kuschkenensis* Grey-Wilson & Mathew, ? *edit.*
- I. lineata* M. Foster 1887
- I. stolonifera* Maximowicz 1880

To my present knowledge, a type of section *Regelia* as circumscribed by Lynch has not previously been designated. After a study of that author's protologue, and in an attempt to preserve both the originally intended and the current usage of *Regelia* (Article 7 B, ICBN), I have selected and here designated *I. korolkowii* Regel as the type of this section.

The *Regelia* species are essentially montane species characterized by more or less stoloniferous rhizomes bearing unbranched scapes each with a 2-bracted spathe containing 2 (rarely 3) flowers with all perianth segments bearded. They differ from all other arillate sections except *Oncocyclus*, with which they show the greatest affinity, in general distribution, plant habit, spathe and/or floral morphology, and, except for chromosome number in *Psammiris* and *Pseudoregelia*, in karyotype. Intersectional hybrids between *Regelia* and the remaining arillate sections (except *Oncocyclus*) have been difficult or impossible to obtain. The rare hybrids produced have been sterile.

In contrast, there is marked fertility in intersectional diploid hybrids between *Regelia* and *Oncocyclus*, and, excepting the large metacentric chromosome of *Regelia* species, a striking similarity of haploid karyotypes in the two sections. The taxa are differentiated, however, by the weakly or non-stoloniferous rhizomes, 1-flowered spathes, and widely scattered beards on the outer perianth segments of *Oncocyclus* species.

Iris section *Oncocyclus* (Siemssen) Baker in Gard. Chron. ser. 3, 5:788 (1876).

Oncocyclus Siemssen in Bot. Zeit., 4:706-707 (1846).—*Iris* subgen. *Susiana* Spach in Ann. Sci. Nat. ser. 3, 5:110 (1846); *idem* in Hist. Nat. Veg., 13:70-71 (1846).—*Iris* subgen. *Oncocyclus* (Siemssen) Alefeld in Bot. Zeit., 21:296 (1863); Baker in Journ. Linn. Soc. Lon. Bot., 16:142 (1877).—*Iris* subsect. *Oncocyclus* (Siemssen) Benthall (1882), *l.c.*; Pax (1888), *l.c.*—*Iris* subgen. *Pogoniris* Randolph in Bull. Amer. Iris Soc., 109:4 (1948), *p.p. affin. gen. Oncocyclus* Siemssen; *non* Spach (1846), *l.c.*; *non* Baker (1876), *l.c.*

Type of the section: *I. paradoxa* Steven.

Species included within the section:

- I. acutiloba* C. A. Meyer 1831
- I. antilbanotica* Dinsmore 1933
- I. atrofusca* Baker 1894
- I. atropurpurea* Baker 1889
- I. auranitica* Dinsmore 1933
- I. barnumiae* M. Foster & Baker 1888
- I. biggeri* Dinsmore 1933
- I. bismarckiana* (Dammann) Regel 1890
- I. bostrensis* Mouterde 1954
- I. camillae* Grossheim 1950
- I. calcaria* Dinsmore *inedit.*
- I. cedretii* Dinsmore *ex* Chaudhary 1972
- I. damascena* Mouterde 1967
- I. demawendica* Bornmueller 1902
- I. ewbankiana* M. Foster 1901
- I. gatesii* M. Foster 1890
- I. grossheimii* Woronov 1928, ? *hyb. nat.*
- I. hauranensis* Dinsmore 1933
- I. haynei* (Baker) Mallet 1904
- I. heylandiana* Boissier & Reuter 1877
- I. hermona* Dinsmore 1933
- I. iberica* Hoffmann 1808
- I. kirkwoodii* Chaudhary 1972
- I. lineolata* (Trautvetter) Grossheim 1950
- I. lortetii* Barbey 1881
- I. lupina* M. Foster 1887
- I. lycotis* Woronov 1915
- I. maculata* Baker 1876
- I. manissadjanii* Freyn 1896
- I. meda* Stapf 1885
- I. nigricans* Dinsmore 1933
- I. paradoxa* Steven 1844
- I. petrana* Dinsmore 1933
- I. polakii* Stapf 1885, *p.p.*
- I. sari* Schott 1876
- I. schelkownikowii* Fomin 1907, ? *hyb. nat.*
- I. schischkinii* Grossheim 1950
- I. sofarana* M. Foster 1899
- I. sprengeri* Siehe 1904
- I. susiana* Linnaeus 1753
- I. urmiensis* Hoog 1900
- I. yebrudii* Dinsmore *ex* Chaudhary 1972

Of the arillate irises, the section *Oncocyclus* is the most refractory to systematic treatment. The situation has resulted from the numerous intraspecific phenotypic variations among populations and collections

of apparently valid species, the frequency of natural hybridization among sympatric species and the use of specific epithets for hybrids and their nothomorphs, and variations in interpretation and use of differentiating criteria among taxonomists. It is possible, therefore, that the list immediately above lacks the names of valid *Oncocyclus* species, and includes names which may be synonymous with others. It should be considered a tentative listing in lieu of more thorough examinations of putative species and hybrids, and of systematic analyses based on characteristics perhaps somewhat more instructive of this section than gross morphology and habitat alone.

The *Oncocyclus* species are found in dry desert and montane habitats from the eastern Mediterranean coastal region east and northeast into Iran, Afghanistan and Turkmenian U.S.S.R. They are characterized by weakly or non-stoloniferous rhizomes, more or less falcate radical leaves, and a scape bearing a 2-bracted spathe containing a single flower. Both inner and outer perianth segments vary remarkably in outline among the species, from the much reduced sepals of *I. paradoxa*, the type for the section, to the narrow and acutely pointed segments of the *I. meda*-*I. acutiloba* complex and the wide rounded perianth of *I. susiana* and similar cultivated species. All, however, possess a beard of multicellular hairs scattered widely and often densely along the haft and onto the blade of the sepal.

Iris section *Psammiris* (Spach) Taylor *comb. nov.*

Iris subgen. *Psammiris* Spach in Ann. Sci. Nat. ser. 3, 5:110 (1846); *idem* in Hist. Nat. Veg., 8:69-70 (1846).

Type of the section: *I. humilis* Georgi.

Species included within the section:

I. bloudowii Bunge *ex* Ledebour 1833

I. humilis Georgi 1775

? *I. mandschurica* Maximowicz 1880

I. potaninii Maximowicz 1880

Because there has been some reluctance to reject *I. flavissima* Pallas as a later synonym for *I. humilis* Georgi, a brief nomenclatural history of this species is included here.

Messerschmidt found a low-growing yellow iris near the Transbaikalian town of Ulan-Ude. Its description ("Iris humilis angustifolia. . . .") was first published by Ammann (1739) after number 133, page 101.

Gmelin (1747) described after his number 31 "iris foliis ensiformibus, caule bifloro. Tab. V. Fig. 2" and included as a synonym "Iris humilis angustifolia. . . . Mess. Amm. (Stirp. rar.) Ruth. post 133." Gmelin stated that his number 31 (as *Ammanni*) had also been observed by Messerschmidt in the hills near Ulan-Ude. It is obvious that Gmelin considered his number 31 to be the same as Messerschmidt-Ammann number 133.

Georgi (1775) again observed the iris in the southern Baikal region, and published the following description of it under the name *I. humilis*: "Iris humilis, angustifolia, lutea. Messerm. Amman. (Stirp. rar.) p. 101. Radix flavo alba fibrosa. Caulis 3. ad 6. pollicum, saepius biflorus, foliis gramineis, duplo longioribus." It is apparent that Georgi considered his *I. humilis* to be the same as Messerschmidt-Ammann number 133 (the only "*iris humilis angustifolia*" on page 101), and his diagnosis is compatible with Gmelin's figure 2, plate V.

In 1776, Pallas published the name *I. flavissima*, and included as a synonym: "Iris foliis ensiformibus. . . . Gmel. Flor. Sibr. I. p. 31. tab. V. fig. 2. cum synon. Ammanni." Thus *I. flavissima* is the same as Gmelin number 31 and therefore Messerschmidt-Ammann number 133, and *I. humilis* Georgi, also conspecific with the latter, is the first validly published name for this species.

Spach (1846) first published *Psammiris* as a monospecific subgenus based on *I. arenaria* Waldst. & Kit., a later synonym of *I. humilis* Georgi. Baker (1877) later combined psammirises with *Pogoniris*, where they remained until Lawrence (1953) transferred them to subsection *Hexapogon*. Although most forms of *I. humilis* have more or less stoloniferous rhizomes and radical leaves which are tinged with anthocyanin pigments at vernal emergence (characteristics sometimes assumed to show affinity with common garden forms of some *Regelia* species), the psammirises differ from other arillate species in karyotype, general distribution range, plant habit and/or floral and rhizome morphology.

The psammiris karyotype (Simonet, 1934; Gustafsson and Wendelbo, 1975) is quite distinct among arillate irises, unlike even those of *Regelia* and *Pseudoregelia* species with similar chromosome numbers (Randolph and Mitra, 1961; Zakhariyeva and Makushenko, 1969). The few intersectional hybrids produced experimentally between *Psammiris* and other arillate species are sterile.

Psammirises are found in open meadows and on hillsides from south-central Europe east into transcaucasian U.S.S.R., and on exposed mountain slopes and in grasslands and shaded, dry mountain valleys from the western Altai region north and east into Mongolia, Manchuria and transbaikal U.S.S.R. They are the most widely distributed of the arillate species, and the only arillate irises native to central Europe.

Although there are some differences in flower stalk length and rhizome morphology among *Psammiris* species and geographical forms of species, all produce narrow radical leaves which frequently dry to leave fibrous vestiges near the rhizome, and thin scapes bearing 1 or 2 2-bracted spathes each with 1 or 2 short-lived flowers with more or less elongated perianth tubes. The withering flowers become characteristically helically twisted (Spach, 1846; Ugrinsky, 1922).

Iris section *Pseudoregelia* Dykes, Gen. Iris, 129 (1913).

Iris subgen. *Pseudoevansia* Baker, Hndbk. Irideae, 2 (1892), *nom. nudum*.—*Iris* sect. *Pseudoevansia* Lynch, Bk. Iris, 55 (1904), *nom.*

nudum.—*Iris* subsect. *Pseudoregelia* (Dykes) Lawrence in Gent. Herb., 8(4):356 (1953); Rodionenko, Gen. Iris L., 199 (1961).

Type of the section: *I. kamaonensis* Wallich ex D. Don.

Species included within the section:

I. goniocarpa Baker 1876

I. hookerana M. Foster 1887

I. kamaonensis Wallich ex D. Don 1841

?*I. leptophylla* Lingelsheim 1922

I. sikkimensis Dykes 1908, ? *hyb. nat.*

I. tigridia Bunge ex Ledebour 1829

Baker (1892) created the subgenus *Pseudoevansia* to include several small central Asian species which he believed were related to the crested *Evansia* species. His differential diagnosis was based exclusively on the rudimentary crests terminating the beard of pseudoevansias, structures now known to have little taxonomic significance. Lynch (1904) retained *Pseudoevansia* as a section, but failed to describe the taxon further. The name remained a *nomen nudum*. Dykes (1913) examined *Pseudoevansia*, transferred some included species to other taxa, and fully characterized and published the name *Pseudoregelia* as a section circumscribing the remaining species. Both Lawrence (1953, 1959) and Rodionenko (1961) retained the name for a subsection with the same circumscription.

The pseudoregelias are essentially montane often alpine species found from the Indian Himalayas north and east into Nepal, Tibet, Mongolia and eastern Siberia, and west into the Altai region. They superficially resemble *Psammiris* species in dwarf plant habit and floral morphology, but differ significantly in rhizome morphology and in karyotype (Simonet, 1952). The known *Pseudoregelia* species exhibit no close affinities with other arillate irises. Fertile intersectional hybrids involving pseudoregelias have not been produced.

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PROCEEDINGS
OF THE
BIOLOGICAL SOCIETY OF WASHINGTON

AFFINITIES OF *PARANIPHARGUS LELOUPARUM*
MONOD, A BLIND ANCHIALINE AMPHIPOD
(CRUSTACEA) FROM THE GALAPAGOS ISLANDS

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Paraniphargus lelouparum Monod, 1970, is the first blind hypogean amphipod known from the Galapagos Islands. A new genus is described for this species to recognize several distinctions it has from *Paraniphargus*. The possibility that the species has sternal gills is refuted, thereby clarifying its relationships.

Terms: "Gammaridan" refers to Gammaridea in the hypothetical group level of Section. "Mark" ("M." refers to a position a stated distance from the proximal end on a scale of 0 to 100. "Melitid gnathopod 1" refers to a small, mitten-form gnathopod with transverse palm, elongate wrist and pubescence on one or more of articles 4-6. "Hadziid gnathopod 2" refers to an enfeebled female gnathopod with elongate wrist, the palm and posterior margin of the hand confluent and both armed with sparse groups of stiff, apically bent, elongate setae. These setae are also found in melitids, such as *Psammoniphargus* Ruffo, but occur on the posterior margin of the hand outside the palm.

Uropod 3 is described in the following terms:

Dispariramus, outer and inner rami dissimilar;

Aequiramus, outer and inner rami similar in length, shape and patterns of armament;

Magniramus, inner ramus extending as far as outer ramus;

Variramus, inner ramus not as long as outer ramus but medial margin with armaments;

Parviramus, inner ramus much shorter than outer ramus and lacking medial armaments, inner ramus usually very short and scalelike.

The presence of a conspicuous article 2 on the outer ramus results in a classification of *dispariramus*; such uropod 3 can be *magniramus*, *variramus* or *parviramus*; an *aequiramus* uropod 3 is always *magniramus* but a *magniramus* uropod 3 can be either *dispariramus* or *aequiramus*.

Galapsiellus, new genus

Type-species: Paraniphargus lelouparum Monod, 1970 (here designated).

Etymology: Contrived. Masculine.

Diagnosis: Coxal gills 2–6, ovate, weakly pedunculate, not 2-articulate. Sternal gills absent. Males and females almost identical except for penial processes of males and weak sausage-shaped oostegites 2–5 on female. Body subvermiform, all coxae very short, of similar length. Uropod 3 *parviramus*, outer ramus 1-articulate, peduncle greatly elongate, about as long as longest ramus on uropods 1–2 and nearly as long as outer ramus of uropod 3. Telson fully cleft, lobes apically turgid, each bearing apicomedial spine. Gnathopods of both sexes enfeebled, gnathopod 1 of melitid form, wrist elongate, anteriorly pubescent, hand weakly trapezoidal, palm scarcely oblique, short, article 4 swollen and pubescent. Gnathopod 2 broader and longer than gnathopod 1, wrist similarly elongate, not pubescent, article 4 similar, not pubescent, article 6 almost twice as long as article 6 of gnathopod 1, about 1.2 times broader, palm oblique. Palms of gnathopods sparsely setose, lacking spines except at defining corners. Wrists of gnathopods unlobate. Mandibular palp article 3 linear, bearing only E setae (apical). Lower lip with weak inner lobes. Medial setae on maxillae absent or sparse. Pleopods biramous. Urosomites free, naked, or with at most one dorsolateral setule on each side.

Galapsiellus lelouparum (Monod)

Paraniphargus lelouparum Monod, 1970:13–25, figs. 6–45.

Description: Blind. Head almost truncate anteriorly, with weak but broad and truncate anterior lobe (less accentuated than shown by Monod). Article 2 of pereopods 5–7 unexpanded, elongate, weakly pyriform; posteroventral corners right angular (or weakly sharpened in Monod's specimens). Basofacial spine of peduncle on uropod 1 situated at Mark 45, apex of peduncle extended and proboscoïd. Dactyl of maxilliped with strong apical nail (not shown by Monod).

New material: Five specimens from JLB GAL 103, Isla Santa Cruz, Galapagos Islands, Academy Bay, mangrove tidepool 300 m from sea near lower bodega of Charles Darwin Research Station, tidepool of

anchialine variety, not connected to sea at surface but fluctuating with tidal level, 23 January 1964, collected by J. L. Barnard. Associated fauna, *Ampithoe* sp., *Cheiriphotis megacheles* (both amphipods) and palaeomonid shrimps.

Observations: One specimen is a definite male, bearing small penial processes on sternite 7 of the thorax. No sternal gills are present. Presumably, therefore, the sausage-shaped appendages noted by Monod on pereonites 2–5 represented brood lamellae of a female, probably attached to the coxae but appearing to Monod to be attached to the sterna. One of these had a seta, also suggesting their identity as oostegites.

Monod's depiction of this species is excellent. New illustrations are therefore not required.

Distribution: Isla Santa Cruz, Galapagos Islands, phreatic and anchialine.

CLASSIFICATION OF GAMMARIDANS

Monod (1970) noted the potential affinities of *Paraniphargus lelouparum* as belonging to the broadly conceived groups proposed by Stephensen (1933) which included such diverse genera as *Niphargus*, *Neoniphargus*, *Paraniphargus*, *Metaniphargus* (= *Hadzia*), *Uroctena*, *Austroniphargus*, *Melita* and *Crangonyx*. He noted also the remarks of Schellenberg (1931) showing how close *Paraniphargus* lies to *Melita* and how Stephensen (1933) placed *Paraniphargus* into a subgroup containing *Niphargus*, *Neoniphargus*, *Niphargopsis*, and *Metaniphargus* (= *Hadzia*).

These genera are now better divided into the following groups, some of which are briefly characterized (see in part, Bousfield, 1973).

I. Crangonychoids (Crangonychidae, Bousfield, 1973). A primitive superfamilial group characterized by either true sternal gills, paddle-shaped calceoli or the presence of densely packed bifid-trifid spines on the palm of male gnathopod 2. Including, for example, most fresh-water genera of Australia (*Neoniphargus* Stebbing, *Uroctena* Nicholls); South Africa (*Paramelita* Schellenberg); *Falklandella* Schellenberg and *Phreatogammarus* Stebbing from Falkland and New Zealand, respectively; *Pseudocrangonyx* Akatsuka and *Procrangonyx* Schellenberg (= *Eocrangonyx* Schellenberg) from east Asia; plus the Holarctic crangonyxes. Numerous other genera.

II. Gammaroids (Gammaridae, Bousfield, 1973). Sternal gills absent. Palm of male gnathopod 2 not densely lined with bifid or trifid spines. Coxal gill 7 present or occasionally absent in apomorphic forms otherwise derivable from gammaroids; or marked by plesiomorphic characters such as tympanic calceoli in males. Eighty-five genera, numerous groupings, examples, *Gammarus* J. C. Fabricius, *Chaetogammarus* Martynov, *Acanthogammarus* Stebbing, *Amathillina* Sars, *Sarothrogammarus* Martynov, *Pontogammarus* Sowinsky, *Micruropus* Stebbing.

A. Anisogammarids. Palms of male gnathopods with peg-spines. *Anisogammarus* Birstein, *Spinulogammarus* Tzvetkova, *Eogammarus* Birstein, *Bathyceradocus* Pirlot, ?*Metaceradocoides* Birstein and Vinogradova (and see below).

B. Mesogammarid. Apomorphic form. *Mesogammarus* Tzvetkova.

C. *Micruropus alaskensis* Bousfield and Hubbard. Apomorphic (new genus, Bousfield, in prep.).

D. *Eoniphargus* Ueno. Apomorphic form with tympanic calceoli.

III. Gammarelloid Groups. One or both gnathopods scarcely or not prehensile, but coxal gill 7 usually retained. Divisible into groups characterized by *Gammarellus* Herbst, *Cheirocratus* Norman, *Hornellia* Walker, *Megaluropus* Hoek, *Argissa* Boeck, *Melphidippa* Boeck and *Macrohectopus* Stebbing.

IV. Hadzioids (Hadziidae, Karaman, 1943; Melitidae, Bousfield, 1973). Sternal gills absent. Coxal gill 7 absent. Gnathopods subchelate except for special form of female hadziid gnathopod 2. Calceoli absent. Loss of any other marker attributes showing immediate descent from Crangonychoids and Gammaroids. Probably polyphyletic and subject to further elaboration.

A. *Melitids*, to contain *Melita* Leach, *Eriopisa* Stebbing, *Dulichella* Stout, *Melitoides* Gurjanova, *Psammoniphargus* Ruffo, and several new genera. Uropod 3 dispariramus. Lower lip with inner lobes. Female gnathopod 2 with distinct palm lacking groups of bent setae.

1. Subgroup to contain *Psammogammarus* S. Karaman, characterized by loss of sexual dimorphism on gnathopod 2, possibly *Eriopisa longiramus* Stock and Nijssen to be distinguished generically by variramus uropod 3. Divergent from ancestors of *Eriopisa*.
2. Subgroup to contain *Paraniphargus* Tattersall characterized by loss of medial setation on maxillae and possibly by loss of sexual dimorphism in gnathopod 2; retaining enlarged coxae unlike subgroup 1. Derivative from *Melita*.
3. Subgroup to contain *Galapsiellus*, new genus, characterized by reduction of medial setation on maxillae, reduction of anterior coxae, partially mittenform gnathopod 2 lacking sexual dimorphism. Derivative from *Eriopisa*.

B. *Hadziids*, to contain *Hadzia* Karaman, *Dulzura* J. L. Barnard and new genera (in part, see Zimmerman and Barnard, in press). Uropod 3 dispariramus. Lower lip lacking inner lobes. Female gnathopod 2 lacking palm but dactyl closing against margin furnished with sparse groups of stiff, elongate, apically bent setae. Other genera removed to weckeliids and ceradocids.

1. *Metacrangonyx* Chevreux. Group characterized by entire telson and miniaturized uropod 3.

C. *Eriopisellids*, to contain *Eriopisella* Chevreux, *Netamelita* J. L. Barnard, *Indoniphargus* Straskraba, and *Microniphargus* Schellenberg. Both sexes with fully mittenform gnathopods.

1. *Bathyonyx* subgroup to contain *Bathyonyx* Vejdovsky. Characterized by especially reduced maxillary spination.

2. *Niphargus pulchellus* Sayce. Australia.

D. Salentinellids, to contain *Salentinella* Ruffo, *Parasalentinella* Bou. Gnathopods mittenform but article 2 of pereopods 5-7 expanded and lobate.

E. Austroniphargids, to contain *Austroniphargus* Monod and a new genus (*Austroniphargus starmuhlneri* Ruffo). Characterized by hammer-like gnathopods bearing lobular wrists. Urosomites coalesced. Possibly of direct crangonychoid descent.

F. Pseudoniphargids, to contain *Pseudoniphargus* Chevreux. Gnathopod 1 of melitid form, hammer-like. Gnathopod 2 enlarged, palm oblique, wrist short, scarcely lobate. Telson almost entire.

G. Niphargids, to contain *Niphargus* Schiödte, *Pontoniphargus* Dancau, *Haploglyngmus* Mateus and Mateus, *Niphargopsis* Chevreux, *Niphargellus* Schellenberg and *Carinurella* Sket. Characterized by hammer-like gnathopods resembling mittens but enlarged, or apomorphically derived from enlarged hammer-like gnathopods lacking palmar spines, wrists unlobate.

H. Ceradocopsids, to contain *Ceradocopsis* Shellenberg (= *Maeracuncha* Stephensen), *?Metaceradocoides* Birstein and Vinogradov. Uropod 3 miniaturized, retaining conspicuous article 2 on outer ramus.

I. Nuuanuids (see McKinney and Barnard, in prep.), to contain *Cottesloe* J. L. Barnard, *Gammarella* Bate, *Nuuanu* J. L. Barnard, and new genus. Uropod 3 miniaturized as in category 9 but article 2 of pereopod 7 broadly expanded, hatchet-shaped.

J. Weckeliids, formerly hadziids, to contain *Weckelia* Shoemaker, *Alloweckelia* Holsinger and Peck, *Mexiweckelia* Holsinger and Minckley, *Mexiweckelia particeps* Holsinger and Minckley (new genus, Holsinger, in prep.). Uropod 3 aequiramus. Female gnathopod 2 enfeebled, palm distinct, lined evenly with weakly bifid spines, posterior bent setae not fully developed on palm. Inner lobes of lower lip weak. Possibly derivative from ceradocids (to follow) or directly from crangonychoids.

K. Ceradocids, to contain all other fully marine gammaridan genera lacking coxal gill 7, bearing gills 2-6, bearing fully subchelate gnathopods, nonvermiform body, normal oostegites and pleopods, uropod 3 basically magniramus and aequiramus except in apomorphic genera. Including *Paraeweckelia* Shoemaker, a former hadziid.

1. Ceradocins.

Infra group a. Ceradocins, *Ceradocus* Costa, *Ceradomaera* Ledoyer, *Paraeweckelia* Shoemaker, *Ceradocoides* Nicholls. Group IVJ weckeliids, probably descend at this point.

Infra group b. Paraceradocins. Antenna 2 with articles 4-5 elongate, slightly thickened. *Paraceradocus* Stebbing, *Quadrivisio* Stebbing.

Infra group c. *Anelasmopus* Oliveira, *Elasmopoides* Stebbing, *Maeropsis* Chevreux, *Maera* Leach.

Infra group d. *Elasmopus* Costa.

Infra group e. *Parelasomopus* Stebbing, *Mallacoota* J. L. Barnard, *Ifalukia* J. L. Barnard, *Beaudettia* J. L. Barnard.

2. *Parapherusa* group. Uropod 1 and uropod 3 aberrant. *Parapherusa* Stebbing.

3. Maerellins. Peduncle of uropod 3 elongate. *Maerella* Chevreux, *Jerbarnia* Croker.

L. Kerguelenioids, to include *Kergueleniola* Ruffo (= *Kerguelenella* Ruffo). Like ceradocopsids but body vermiform.

V. Bogidiellids, to include *Bogidiella* Hertzog, *Bollegidia* Ruffo. Body vermiform, coxal gills reduced to 4 pairs, brood plates with dense setae confined terminally, some brood plates geniculate.

VI. *Pseudogolfiella* Noodt.

PROBLEMS OF CONVERGENCE

The higher classification of gammaridean Amphipoda is fraught with difficulties, among them convergence. The problem of the third uropod in hadziids is just one of many for which morphologists alone may never have answers. For example, crangonychoids (Bousfield, 1973) are marked either by sternal gills or bifid spines densely lining one or more of the gnathopodal palms. Because loss of structure is the trend in gammaridean evolution, the loss of these gills and spines could result in a host of descendants unrecognized in other superfamilies. Characters frequently do not occur universally in a higher taxon of amphipod, though closely related or inclusive taxa can often be recognized by marker attributes. Some crangonychoids lose sternal gills, some lose coxal gill 7 and others lose bifid palmar spines, but if the first and last are present, or if an apomorphic species can otherwise be adjoined in an obvious evolutionary sequence, then one may recognize a crangonychoid. *Eoniphargus* Ueno, for example, a Japanese hypogean gammaroid, might have crangonychoid ancestry except that the male calceoli are tympanic, rather than paddle-shaped. By that character, *Eoniphargus* is also not a member of the greater hadzioids and probably should be derived from a gammaroid (greater Gammaridae) ancestry, even though coxal gill 7 is absent. A geographic companion, *Awacaris* Ueno, is clearly analogous to *Eoniphargus* in scores of attributes, though uropod 3 is aequiramus, whereas uropod 3 of *Eoniphargus* is dispariramus and parviramus. *Awacaris* therefore appears related to the marine ceradocins and the bogidiellids with aequiramus uropod 3 but its gnathopods are far more apomorphic than those of *Eoniphargus*, which has the apomorphic uropod 3. However, it also shows plesiomorphy in the almost imperceptible remnant of article 2 on the outer ramus. Uropod 3 of *Phreatogammarus* (crangonychoid) also is aequiramus in contrast to all of its congeners. The dispariramus uropod 3 greatly resembles that of Notogean syncarids and

could be conceived as a plesiomorphic attribute, but the aequiramus uropod 3 would have to be derived from that plesiomorphic condition by loss of article 2 on the outer ramus without concomitant reduction of the inner ramus. Most of the ceradocid marine gammaroids possess the aequiramus uropod 3 but it is also present in the weckeliids and in the bogidiellids, kerguelenioids, awacarids and phreatogammarids. The aequiramus uropod 3 also has the rami more or less equal in thickness and armaments. The greater proportion of gammaridans carry the dispariramus uropod 3, or its derivatives, with the outer ramus incipiently or fully biarticulate and the inner ramus of diverse shapes and lengths. Ancestry in taxa with severe reduction in any component of uropod 3 cannot necessarily be traced. The aequiramus uropod 3 can be shown to be ancestral to the fully parviramus stage (as seen in the marine *Beaudettia* J. L. Barnard) as much as can the dispariramus uropod 3.

The probability is high that a consistent evolutionary trend in uropod 3 dominates the amphipods but much elucidation is required before this trend can be perceived. The question is very basic to the origins of Gammaridea because either the gammarid-like amphipods or the photidcorophiid amphipods such as *Gammaropsis*, characterized by fleshy telson and generally by aequiramus uropod 3, are presumed to be the most primitive living gammarideans. The ultimate question is whether or not the dispariramus uropod 3, associated generally with freshwater amphipods, is the more primitive and therefore signals a freshwater, Notogean, syncarid ancestry. In this evolutionary sequence one would assume that sternal gills mark the primitive state and that *Phreatogammarus*, isolated in New Zealand, would be the most plesiomorphic of the aequiramus and sternobranchiate forms, perhaps anticipatory to invasion of the sea. On the other hand, the fleshy telson of corophioids, coupled with the typical aequiramus uropod 3 of marine gammarideans may mark the ancestral stock, in which case the dispariramus uropod 3 is an apomorphic development.

AFFINITIES OF GALAPSIELLUS

Galapsiellus differs from *Paraniphargus* in the elongate peduncle of uropod 3, the size reduction of gnathopod 2 in both sexes, and the distad position of the basofacial spine on uropod 1. Gnathopod 2 approaches the mittenform-shape found in *Eriopisella* and its allies but is significantly larger than gnathopod 1 and the hand is weakly expanded apically in contrast to the eriopisellid genera.

Reduction of gnathopod 2 in male gammaridan amphipods is a common generic character. It typifies the eriopisellids, another group of genera known as weckeliids and other scattered genera of the gammaridan group. This characteristic is especially prevalent in anchialine or phreatic or anoculate groups.

Monod was undoubtedly correct in assuming a relationship of *G. lelouparum* to *Paraniphargus*. That genus, with two species, occurs

on western Pacific and Indian Ocean islands in freshwaters and presumably the species are basically hypogean although the type-species, *P. annandalei* Tattersall, 1925, was found among matted rootlets of a jungle stream at 152–244 m altitude in the South Andaman Islands, whereas the second known species, *P. ruttneri* Schellenberg, 1931, was found in a well in east Java.

Paraniphargus has the primitive gnathopod 2 exhibited by contiguous marine amphipods such as *Melita*, an enlarged appendage with short and weakly lobate wrist, and has the primitive uropod 3 with shortened peduncle.

Paraniphargus can be derived from a widely distributed tropical and temperate marine genus, *Melita*, with more than 50 species, often found in estuaries or in anchialine situations. *Paraniphargus* differs from *Melita* in the complete loss of medial setation on the maxillae. *Paraniphargus* is not well-known but one would suspect that it is also characterized by a loss of sexual dimorphism in gnathopod 2, which in *Paraniphargus* is a blend between male and female conditions of *Melita*. The loss of article 2 on the outer ramus of uropod 3 and the loss of all but E setae on mandibular palp article 3 are but extensions of conditions almost fully expressed in several marine species of *Melita*. *Paraniphargus* maintains the fleshy inner lobes typical of Indo-Pacific species of *Melita*. *Galapsiellus* carries the trends of reduction and sexual stabilization in gnathopod 2 to an extreme almost typical of eriopisellids. This group of genera, containing *Eriopisella* Chevreux, *Netamelita* J. L. Barnard, *Indoniphargus* Straskraba and *Microniphargus* Schellenberg, is characterized by fully mittenform gnathopods. Gnathopod 1 retains the melitid (mittenform) form but gnathopod 2 is reduced to the same size and has some of the same characteristics, such as medial or posterior pubescence and elongate wrist. In *Microniphargus* and *Indoniphargus* the gnathopods are axially reversed in contrast to *Eriopisella* as marked by the presence of a pubescent posterior lobe on the wrist of gnathopod 1, which in *Eriopisella* occurs on gnathopod 2. Eriopisellids also tend to be blind and anchialine and some of them, *Microniphargus* and *Indoniphargus*, have penetrated fully into phreatic waters of Belgium and India.

Galapsiellus is not on eriopisellid because its gnathopods are somewhat more primitive, though, like *Paraniphargus*, it could lie ancestral to eriopisellids. This group and the eriopisellids could also lie ancestral to niphargids.

Galapsiellus bears a remarkable resemblance to the enigmatic *Bathyonyx* Vejdovsky, 1905, from Lough Mask, a lake of Ireland. The body of *Galapsiellus* is more vermiform but the odd shape of the anterior coxae, weakly sinuous posteroventrally, is similar. In *Galapsiellus* much of this sinuosity can actually be eliminated by pressing the coxae very flat. The large, almost truncate head of *Bathyonyx* is very similar to that of *Galapsiellus*. *Bathyonyx* also has mittenform gnathopods with elongate wrists but they are closer to the eriopisellid kind than to

the galapsiellin kind because they are identical in size or gnathopod 1 is very slightly the larger. *Bathyonyx* is characterized by the retention of medial setae on maxilla 2 (maxilla 1 inner plate is unknown), the outer plate of maxilla 1 has the spines reduced to 4, uropod 3 is parviramus but the peduncle is short and the outer ramus is 2-articulate, the mandibular palp article 3 is more tumid and setose, and the telson is elongate.

Geographically and temporally *Galapsiellus* bears no relationship to crangonychoids, though apomorphic crangonychoids would be difficult to detect once the sternal gills, coxal gill 7, urosomal setation and bifid palmar spines were lost. Crangonychoid distribution appears to have been a product of Pangaea in the early Mesozoic. Crangonychoids are strictly of freshwater provenance and probably were widely distributed over the coalesced continental masses. They have survived primarily in Notogea, South Africa, and Nearctica with an outpost in the Falkland Islands. In Palearctica they were largely replaced by modern gammaroid genera but never reached Neotropica. There is no nearby source of crangonychoids to postulate an origin for *Galapsiellus* and the Galapagos Islands are too youthful to retain relicts of Pangaea.

Galapsiellus can also be derived from the widespread marine genus *Eriopisa*. The similarity between these genera is even greater than between *Galapsiellus* and *Paraniphargus*, because *Eriopisa* possesses the shortened anterior coxae not typical of *Paraniphargus*. Many species of *Eriopisa* have female gnathopod 2, and occasionally male gnathopod 2, more strongly reduced than in *Paraniphargus*, although none of them has gnathopod 2 as enfeebled as in *Galapsiellus*. *Eriopisa* is more plesiomorphic than either *Paraniphargus* or *Galapsiellus* in maxillae and uropod 3 and therefore could be ancestral to *Galapsiellus* but not to *Paraniphargus*. Uropod 3 of *Eriopisa* bears a moderately to well-developed article 2 and the medial margins of one or both maxillae bear setae. *Eriopisa* may not be directly descendent from ancestors like *Melita* because uropod 3 of the most primitive species of *Eriopisa*, *E. longiramus* Stock and Nijssen, is magniramus, a condition plesiomorphic to the parviramus uropod 3 of *Melita*. *Eriopisa longiramus* and *E. caeca* (S. Karaman) should be reestablished in *Psammogammarus* S. Karaman and differentiated from *Eriopisa* by loss of sexual dimorphism in gnathopod 2 and the evenness of spination on the palm of gnathopod 2 in the female. *Eriopisa longiramus* may further be distinguished generically as uropod 3 is almost magniramus, like *Pontoniphargus* Dancau.

Galapsiellus bears a resemblance to the *Maerella* subgroup of the *Ceradocus* group because of the elongate peduncle on uropod 3 and the shape of the telson. Male gnathopod 2 of *Jerbarnia* in that group has undergone an elongation reminiscent of *Galapsiellus* but otherwise the number of evolutionary steps between *Jerbarnia* (Micronesian marine) and *Galapsiellus* is far greater than between *Eriopisa* and *Galapsiellus*.

The occurrence of a phreatic amphipod in the Galapagos is striking because of the isolation of the archipelago from the mainstream of gammaridean dispersal and evolution. Nearby South America has only *Ingolfiella* Hansen (suborder Ingolfiellidea) and *Pseudoringolfiella* Noodt (suborder Gammaridea) occurring in its phreatic waters. *Galapsiellus* is very remote from those taxa and clearly has a marine origin.

In the Galapagos Islands, *Galapsiellus* has been collected (Monod and herein) in brackish anchialine waters presumed to be a mixture of intruding seawater and phreatic freshwaters percolating downslope to the sea from the highlands of Santa Cruz Island. Brackish sinkholes and emergent aquifers in mangrove swamps are often sufficiently fresh to be potable (5 ppt) and are so used by inhabitants of the island (pers. observ.). The presence of *Ampithoe* and *Cheiriphotis* in my sample suggests that *Galapsiellus* lived in far saltier water than 5 ppt as those genera are strictly marine. The mangrove pond I sampled may actually be a stratified pool of differing salinities so that my broadly cast sample may have covered several salinity regimes. If *Galapsiellus* is an emergent phreatic genus, the specimens of *Galapsiellus* may actually have been dying of exposure to high salinities as I caught them. On the other hand, the genus may be euryhaline and this may help to explain its immigrational adaptability from the sea.

CONCLUSION

Galapsiellus is considered to be an apomorphic melitid with the same kind of phreatiform adaptations found in the eriopisellids and nipargids. The best ancestral fit lies near *Eriopisa* although close morphological similarity occurs with *Paraniphargus*.

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PROCEEDINGS
OF THE
BIOLOGICAL SOCIETY OF WASHINGTONA NEW SPECIES OF *ARICIDEA* (POLYCHAETA:
PARAONIDAE) FROM FLORIDA

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A new species of the genus *Aricidea* (Paraonidae) from the Indian River lagoon of the east coast of Florida is described below. Specimens were collected by Dr. David K. Young and his staff of the Smithsonian Institution's Fort Pierce Bureau (FPB). Additional specimens from the west coast of Florida, collected by Dr. John L. Taylor and Mr. Stuart L. Santos and deposited in the National Museum of Natural History (USNM), were examined and referred to the new species.

I am grateful to Dr. Young for the loan of specimens from the Indian River, to Ms. Ruth Swanson, Dr. Donald Maurer, and Dr. Les Watling for useful criticism during preparation of the manuscript, and to Sandy Steele for careful typing of the final draft. I particularly wish to thank Dr. Marian H. Pettibone of the Smithsonian Institution for the loan of specimens, for considerable assistance with some of the literature and systematic problems, and for critically reviewing the manuscript. Types are deposited in the Smithsonian Institution (USNM). This is contribution 109, University of Delaware, College of Marine Studies.

PARAONIDAE Cerruti

Aricidea Webster*Aricidea philbinae*, new species

Material examined: Holotype (USNM 53172) and one paratype (USNM 53173): Indian River lagoon adjacent to Hutchinson Island, Ft. Pierce, Florida (20°20.9'N, 80°15.7'W), on *Halodule wrightii* grassflats, 1 m, in muddy sand, collected 12 April 1973. Four paratypes (USNM 53174): Indian River lagoon just N of St. Lucie Inlet, St. Lucie,

Florida (27°10.9'N, 80°10.3'W) on *H. wrightii* grassflats, intertidal to 1 m, in muddy sand, collected 16 November 1974. Other specimens: about 50 animals in Indian River lagoon ranging from Titusville, Florida (just N of Haulover Canal) (28°44.1'N, 80°45.5'W) to just N of St. Lucie Inlet, St. Lucie, Florida, intertidal to 1 m, collected 1974–1975, on *H. wrightii* grassflats, several bottom stations, D. K. Young and staff, collectors. Tampa Bay, Florida (27°47'N, 82°40'W) (USNM 48936) 26 specimens, collected September 1971, J. L. Taylor, collector. Tampa Bay, Florida (USNM 48936) 3 specimens, collected 27 October 1969, S. L. Santos, collector. Lassing Park, St. Petersburg, Florida (27°45.2'N, 82°37.7'W) (USNM 50280/1) 9 specimens, collected 18 April and 20 July 1970, S. L. Santos, collector.

Description: Length up to 12 mm, width up to 0.5 mm, up to 77 segments, several ovigerous. The 4 ovigerous specimens ranged from 9.8–10.6 mm long and 0.36–0.44 mm wide. Body cylindrical, widest in branchial region, tapering and flattened dorsoventrally more posteriorly. Prostomium subtriangular (Fig. 1b, c), rounded anteriorly, fused with achaetous buccal segment, forming lateral lips of ventral mouth. Posterior lip of mouth formed by anterior edge of first setiger. Median antenna clavate, short, extending to setiger 2, unequally bifid distally, with smaller subterminal process (Fig. 1c) or rarely with asymmetrical terminal process (Fig. 1b). Cilia present on distal tips of bifid antenna. Nuchal slits posterolateral to median antenna. Pigment spots sometimes present anterior to nuchal slits, as well as on anterior region of body, particularly on dorsal surface. Branchiae 13–15 pairs, beginning on setiger 4. Branchiae widest proximally, tapering to rounded tips and overlapping slightly middorsally (Fig. 1a, c). Anterior 7–10 branchial pairs usually longer and more robust. Single small orbicular papilla posterior to and hidden by branchia on branchial segments (Fig. 1a). Notopodial postsetal lobes small, spherical on first 2 setigers, more elongate on third, subulate in branchial region (Fig. 1a, c) becoming more slender and cirriform in postbranchial region (Fig. 1e). Dense bundles of basally thickened and evenly tapered capillary setae in prebranchial and branchial regions, numbering about 10 in notopodia and about 15 in neuropodia. Anterior postbranchial setigers with finer capillary setae, numbering about 5 in notopodia and 7 in neuropodia. Posterior notopodia with about 3 (2–5) slender capillaries. Modified neuropodial hooks beginning on about setiger 22 (19–24). Neuropodia with about 5 (3–7) very slender capillaries and 5 (4–8) modified neurosetae (Fig. 1e). Modified neurosetae hooked or curved distally, with terminal arista (apparently fragile, sometimes absent), with small subterminal spine on concave side (perhaps part of subterminal hood) (Fig. 1d, e). Pygidium with pair of small anal cirri.

Etymology: It gives me great pleasure to name this species for Maybelline Philbin, who was an unparalleled source of inspiration prior to the preparation of this manuscript.

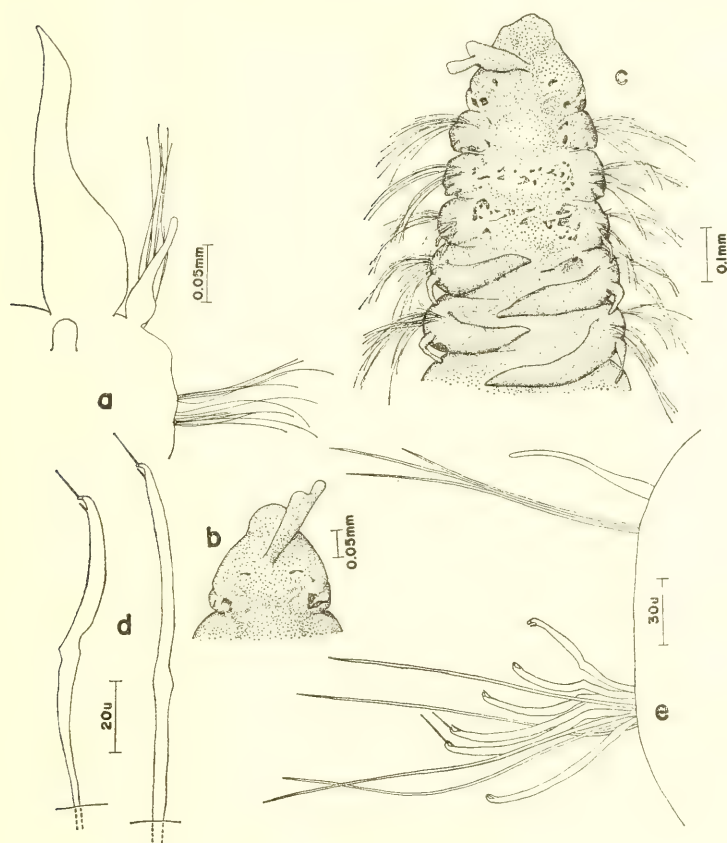


FIG. 1. *Aricidea philbinae*, new species: a, Parapodium from branchial region, posterior view; b, c, Anterior ends of 2 different specimens, dorsal view; d, Modified neurosetae from posterior parapodium; e, Posterior parapodium, posterior view.

Distribution: East and west coasts of Florida. Intertidal to 1 m.

Remarks: *Aricidea philbinae* is close to *Aricidea jeffreysii* (McIntosh) which was described by Pettibone (1965:134) for paraonids from Virginia. Cerruti first used *Aricidea jeffreysii* (McIntosh) when he established the family Paraonidae. Since then, it has been used widely as *A. jeffreysii sensu* Cerruti by numerous authors. Strel'tsov (1973) presented a thorough revision of the family Paraonidae in which he reexamined many specimens including type material. After reviewing the holotype of *Scolecoplepis* (?) *jeffreysii* McIntosh, 1879, from the Davis Strait, he concluded (1973:106, 159) that it should

be an indeterminable *Aricidea* sp. He did so because the type-specimen was a fragment of 26 anterior segments lacking the modified posterior neurosetae necessary for diagnostic species description. Therefore, McIntosh's name should not be used and all the subsequent records of *A. jeffreysii* have needed to be referred to other species. Many of them were referred by Laubier (1967:102) and Strel'tsov (1973:105) to *Aricidea* (*Acesta*) *cerrutii* Laubier, 1966.

Strel'tsov (1973:91, 159) examined 6 paratypes of *Aricidea* (*Acesta*) *catherinae* Laubier, 1967, from the Mediterranean (Banyuls-sur-Mer, France). After examining specimens of each of the following species, he referred them to *A. (Acesta) catherinae*: the records of *A. jeffreysii* by Pettibone (1963, 1965); the records by Hartman of *Aricidea lopezi* (1963:38, as *A. lopezi*, not Berkeley and Berkeley); and *Aricidea zelenzovi* Strel'tsov, 1968. From material on loan from USNM, I examined 3 paratypes of *A. catherinae* from France (USNM 35914) and numerous specimens identified as *A. jeffreysii* by Pettibone from Maine (USNM 28940), Massachusetts (USNM 28935, 31496/7) and Virginia (USNM 31498-31500). These specimens agreed for the most part with the descriptions of *Aricidea catherinae* by Laubier (1967:112) and Strel'tsov (1973:91). None of the specimens showed a bifid antenna as found on *A. philbinae*. The revised distribution of *A. catherinae* (Strel'tsov, 1973) therefore, is: Atlantic coast of North America (from Gulf of St. Lawrence to Chesapeake Bay), coast of Uruguay, Mediterranean, Barents Sea, region of Kurile Island, off Southern California, in 2 to 1929 m.

Aricidea catherinae and *A. philbinae* agree in the following characters: Median antenna is relatively short; branchiae begin on setiger 4; notopodial postsetal lobes are small, bulbous on first 2 setigers, subulate and cirriform more posteriorly; absence of modified setae in notopodia; neuropodial lobes lacking; modified setae found in posterior parapodia, possessing terminal aristae and short, subterminal spines ("hoods").

Median Antenna: The median antenna of *A. catherinae* is enlarged in the midregion by a varying amount and is thinner distally. This agrees with Laubier (1967:114, Fig. 4a, b, c) and Strel'tsov (1973:91). Strel'tsov's (1973) illustration of the dorsal view of the median antenna might lead one to believe that it supports a secondary process. This is not the case, as he states in the text and as I have observed in examination of specimens. On the *A. catherinae* identified as *A. jeffreysii* by Pettibone (USNM 28935, 28940, 31496-31500) and examined by me, the swelling of the midregion of the antenna was so reduced as to appear subulate.

Branchiae: Strel'tsov (1973:91) found that the number of branchial pairs of *A. catherinae* varied with the size of the specimen, smaller specimens (0.15 mm width) with 8-12 pairs and larger ones (0.7-0.9 mm) with up to 25 pairs. *A. philbinae* has 13-15 pairs of branchiae and a maximum width of 0.5 mm.

Setae: The modified neurosetae of *A. catherinae* and *A. philbinae* are similar possessing terminal aristae and a short, subterminal spine (or "hood"). The "hoods," visible on the concave side, are very difficult to observe. In examination of the paratypes of *A. catherinae*, Strel'tsov (1973) observed a short, spinelike structure below the tip of the seta on the concave side, probably corresponding to a part of the "hood." My observations of specimens borrowed from the USNM correspond with this. Distinct hoods on the modified setae were depicted by Laubier (1967:Fig. 5a-d). The appearance on the modified neurosetae as having hoods or short, subterminal spines seems dependent upon the optical equipment of the observer.

Strel'tsov (1972:150) documented the setal morphology of the family Paraonidae. He described 3 main groupings concerning the development of specialized setae within the family. The first group, found on the dorsal parapodial branches of the branchial and postbranchial segments, includes lyrate setae and aciculate setae bearing spines. Setae of the second and third groups are distributed on the ventral branches of the postbranchial parapodia. Group 2 contains "pseudocompound" setae, hooked setae with a subterminal spine and "hooded" setae. According to Strel'tsov's illustration (1972:90, Fig. 1) group 2 setae may be distally curved. Group 3 includes thickened setae, setae with a terminal spine, and various hook-shaped setae which lack spines. These may be either smooth or possess thin hairs on their distal ends. The classification of the setae of *A. philbinae* in this scheme is uncertain. They possess the character of group 3 by having a terminal spine and by being hook-shaped. There is no indication of pubescence on the setae nor do they appear thickened. However, they also possess a hood or a short subterminal spine (as discussed earlier) giving them the character of group 2.

In Florida, *A. philbinae* has been collected in association with *Aricidea fragilis* Webster, 1879 and *Aricidea taylori* Pettibone, 1965 (Pettibone, 1965:129, 131). These 3 species differ in the following characters:

	<i>A. fragilis</i>	<i>A. taylori</i>	<i>A. philbinae</i>
Median Antenna	Subulate	Clubbed	Clavate, bifid
Branchiae	50-60 pairs	26-29 pairs	13-15 pairs
Posterior Modified Neuropodial Setae	Stouter basally, tapering abruptly in midregion to capillary tips, sometimes fractured at mid-point	Bidentate, aristae arise terminally between teeth	Unidentate, curved distally, with short subterminal spine (hood), terminal aristae

Pettibone (1965:131) described the median antenna of *A. taylori* as "short, extending at most to first setiger, clubbed (one paratype with distal tip bifid, evidently an anomaly. . .)." The holotype and paratype (USNM 31494/5) were examined and the terminally bifid setae and median antenna were as described. The anomalous paratype could not be located (according to Pettibone in correspondence, one paratype was sent to Dr. Laubier in exchange, the other paratype apparently has been lost). The relationship of its setae and antenna to those of *A. philbinae* could not be determined.

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PROCEEDINGS
OF THE
BIOLOGICAL SOCIETY OF WASHINGTONOCCURRENCE OF THE CARIBBEAN STOMATOPOD,
BATHYSQUILLA MICROPS, OFF HAWAII, WITH
ADDITIONAL RECORDS FOR *B. MICROPS* AND
B. CRASSISPINOSA

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During the sampling program of the National Marine Fisheries Service (NMFS) aboard the NOAA research vessel TOWNSEND CROMWELL in 1972, one specimen of an unusual stomatopod was taken by trawl off Maui, Hawaiian Islands, at a depth of 731-786 m. It proved to be an adult female of the rare *Bathysquilla microps* (Manning, 1961), then known from only three specimens taken in 732-952 m off southeastern Florida and the Bahamas (Manning, 1969a).

Bathysquilla microps was the second species of bathysquillid to be recognized, the first being *B. crassispinosa* (Fukuda, 1909), originally described from Japan and subsequently recorded from additional localities in the western Indian Ocean. It occurs in depths between 230 and 310 m. A third bathysquillid representing another genus, *Indosquilla manihinei* Ingle and Merrett, 1971, was described from a unique specimen taken off Cosmoledo Atoll, Indian Ocean, in a depth of 420 m. Apparently bathysquillids are restricted to moderate depths of the outer shelf and upper slope (Fig. 2).

The bathysquillids live in far greater depths than the majority of known stomatopods. The deepest record given by Kemp (1913) in his monograph of the Indo-West-Pacific stomatopods was 370-419 fm (677-767 m) for *Squillaoides leptosquilla* from the "Investigator" collections. Chopra (1939) described

Eurysquilla sewelli from 695 m in the Gulf of Aden and recorded two species from 1295 m in the same area. However, these two species, *Gonodactylus chiragra* (Fabricius) and *Oratosquilla investigatoris* (Lloyd), are known to live in much shallower water (especially *G. chiragra*, an intertidal species), and their occurrence at this depth is questionable. In a review of the western Atlantic stomatopods, Manning (1969a) recorded 14 species from depths greater than 300 m, and only two of these, *B. microps* (732–952 m) and *Squilla intermedia* Bigelow (291–615 m), occurred in depths greater than 450 m.

In reporting this unusual extension of range, we present here additional northwestern Atlantic records for *B. microps*, based on collections made since 1969 by the National Marine Fisheries Service, additional records for *B. crassispinosa*, and comparative diagnoses and sketches for both of these species.

Terms and indices used in the accounts below have been discussed in Manning (1969a). All measurements are in millimeters; total length (TL) is measured on the midline from the anterior margin of the rostral plate to a line between the apices of the submedian teeth of the telson. Station data for the OREGON II collections are on file in the Department of Invertebrate Zoology (Crustacea), National Museum of Natural History, Smithsonian Institution. All specimens are in the Smithsonian.

The illustrations were prepared by Lilly King Manning.

Bathysquilla crassispinosa (Fukuda, 1909)

Figures 1a–c, 2

Lysiosquilla crassispinosa Fukuda, 1909:61, pl. 5, fig. 4.

Bathysquilla crassispinosa.—Holthuis, 1967:27 [synonymy to 1967].—

Manning 1969a:95, 98.—Holthuis and Manning, 1969:fig. 350–2.—Ingle and Merrett, 1971:197.

Material: Shikoku Island, Tosa Bay, Japan: 1 ♀ TL (total length) 240 mm.—Madagascar; 18°54'S, 43°55'E; 280–310 m; A. Crosnier, leg.; 24 November 1973: 1 ♀ TL 215 mm.

Diagnosis: Cornea (Fig. 1a) subglobular, fully pigmented, set obliquely on stalk. Rostral plate (Fig. 1a) with distinct median longitudinal groove. Antennal protopod with 2 papillae. Dactylus of claw with 9–10 teeth. Carpus of claw with 2 dorsal spines (Fig. 1b). Intermediate carinae prominent on thoracic and anterior 2 abdominal somites, unarmed. Third to fifth abdominal somites lacking spinules on posterior

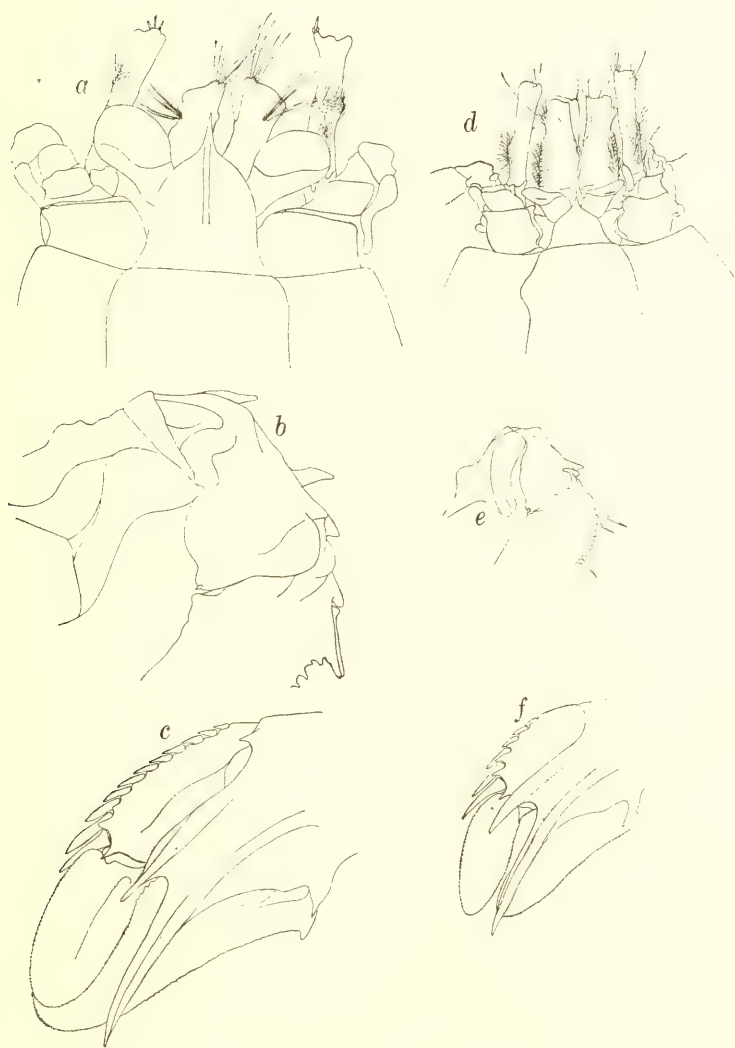


FIG. 1. Front, carpus of claw, and basal prolongation of uropod of:
 a-c, *Bathysquilla crassispinosa* (Fukuda), female from Madagascar;
 d-f, *Bathysquilla microps* (Manning), female from Hawaii.

margin. Telson with submedian swellings anteriorly, lacking distinct dorsal submedian carinae. Proximal segment of uropodal exopod with distinct distal spine dorsally, with 10–13 movable spines laterally. Basal segment of uropod (Fig. 1c) with spine ventrally at articulation of exopod, endopod with inner basal spine.

Remarks: Although Manning (1969a:95) suggested that the Japanese and South African populations of this species might be distinct, based on discrepancies between published figures, Ingle and Merrett (1971) compared material from the two areas and could find no differences. We observed no differences between our specimens from Japan and Madagascar.

On our specimens of *B. crassispinosa*, the intermediate carinae of the eighth thoracic somite may have a minute, sharp tubercle, but the carinae are not obviously armed posteriorly as in *B. microps*. The posterior segments of the abdomen are more heavily granulated dorsally than in *B. microps*. The merus and propodus of the claw are strongly inflated in large males (TL 285 mm from Tosa Bay, Japan; reported by Ingle and Merrett, 1971), and the strongly curved dactylus has an angular projection as in large males of *Harpiosquilla* (Manning, 1969b), but the antepenultimate tooth of the claw is not reduced as in *B. microps*.

The eyes of *B. crassispinosa*, unlike those of *B. microps* and *I. manihinei*, are relatively large and the cornea is fully pigmented. This must be a reflection of its occurrence in shallower waters than either of the other two bathysquillids.

Komai (1938:270) noted that "the ground color is of the bright orange-red very commonly found in deep-sea crustaceans. The color is especially bright on the exposed thoracic and abdominal somites particularly on the anterior and posterior margins of each somite. The carapace, raptorial limbs and telson are relatively light in color. On the ventral side the pleopods are crimson-red."

Bathysquilla crassispinosa is a large stomatopod, attaining a total length of almost 300 mm; only two other stomatopods, *Lysiosquilla maculata* (Fabricius) and *Harpiosquilla raphidea* (Fabricius), are known to grow to this size. Females of *B. crassispinosa* 200–297 mm long have been recorded in the literature; males appear to be only slightly smaller, with total lengths ranging from 245 to 280 mm.

Our specimens have 2–3 movable and 10–12 fixed propodal spines. The propodal indices are similar to those of *B. microps* 076–078 in two large males examined (TL 250–285 mm) and 070 in a female 215 mm long.

A feature which apparently has escaped notice in the past is the presence, in both species of *Bathysquilla*, of a minute movable tooth at the inferodistal angle of the outer surface of the carpus of the claw (Figs. 1b, e). So far as we are aware such spines are found in no other stomatopods.

Distribution (Fig. 2): Indo-West-Pacific region, from Japan,

the western Indian Ocean, and off South Africa, in depths ranging from 230 to 310 m. Records include JAPAN: Sagami Sea (Fukuda, 1909, 1910); deep part of Sagami Sea (Komai, 1938); off Owase, ca. 300 m (Komai, 1927); Shikoku Island, Tosa Bay (Ingle and Merrett, 1971); Shikoku Island, Tosa Bay, 230–295 m.—MADAGASCAR: 18°54'S, 43°55'E, 280–310 m.—MOZAMBIQUE: 25°12'S, 34°04'E; 230–295 m (Ingle and Merrett, 1971).—SOUTH AFRICA: Off Natal, north of Durban, 150 fm (275 m) (Calman, 1923; Gordon, 1929; Ingle and Merrett, 1971); off Durban, 29°42'S, 31°29'E, 132 fm (242 m) (von Bonde, 1932; Barnard, 1950; Ingle and Merrett, 1971).

Bathysquilla microps (Manning, 1961)

Figures 1d–f, 2

Lysiosquilla microps Manning, 1961:693, fig. 5, pls. 10–11.

Bathysquilla microps.—Holthuis 1967:28 [references].—Manning 1969a: 95, Figs. 26–28.

Material: Gulf of Mexico, Bay of Campeche, Mexico; 700 fm (1281 m); OREGON II Station 10957: 1 ♂ TL 112.5 mm.—Gulf of Mexico, south of Panama City, Florida; 395 fm (723 m); OREGON II Station 10635: 1 ♀ TL 175 mm.—North Atlantic, off Surinam; 681–769 m; OREGON II Stations 10604, 10620, 10796: 1 ♂ TL 187 mm, 2 ♀ TL 173–220 mm.—Off French Guiana; 604–769 m; OREGON II Stations 10614, 10616, 10803, 10816, 10822: 4 ♂ TL 176–255 mm, 2 ♀ TL 183–195 mm.—Pacific Ocean, near Maui, Hawaiian Islands; 21°04'N, 156°09'W; 731–786 m (400–430 fm); 12.5 m shrimp trawl; TOWNSEND CROMWELL Station 61–66; 26 October 1972: 1 ♀ TL 201 mm.

Diagnosis: Cornea (Fig. 1d) indistinctly bilobed, set very obliquely on stalk, pigmented part reduced to small, transverse bar. Rostral plate (Fig. 1d) not grooved longitudinally. Antennal protopod with 2 papillae. Dactylus of claw with 13–15 teeth (14 in Maui specimen). Carpus of claw (Fig. 1e) with 1 dorsal spine. Intermediate carinae of body prominent, armed posteriorly on eighth thoracic and usually on second to sixth abdominal somites, also on first somite in Hawaiian specimen. Third to fifth abdominal somites variously ornamented with spinules on posterior margin. Telson with distinct dorsal submedian carinae. Proximal segment of uropodal exopod unarmed dorsally, with 6–8 (6 only in Maui specimen) movable spines laterally. Basal segment of uropod (Fig. 1f) unarmed ventrally at articulation of exopod, endopod unarmed on inner margin.

Remarks: The Hawaiian specimen of *B. microps* agrees in almost all respects with our material from the western Atlantic. The only major difference that we observed was that the Hawaiian specimen has armed intermediate carinae on the first abdominal somite, whereas the intermediate carinae of this somite are unarmed in all of our Atlantic specimens. This single difference in one specimen is not, in our opinion, enough to warrant recognizing a separate Hawaiian subspecies.

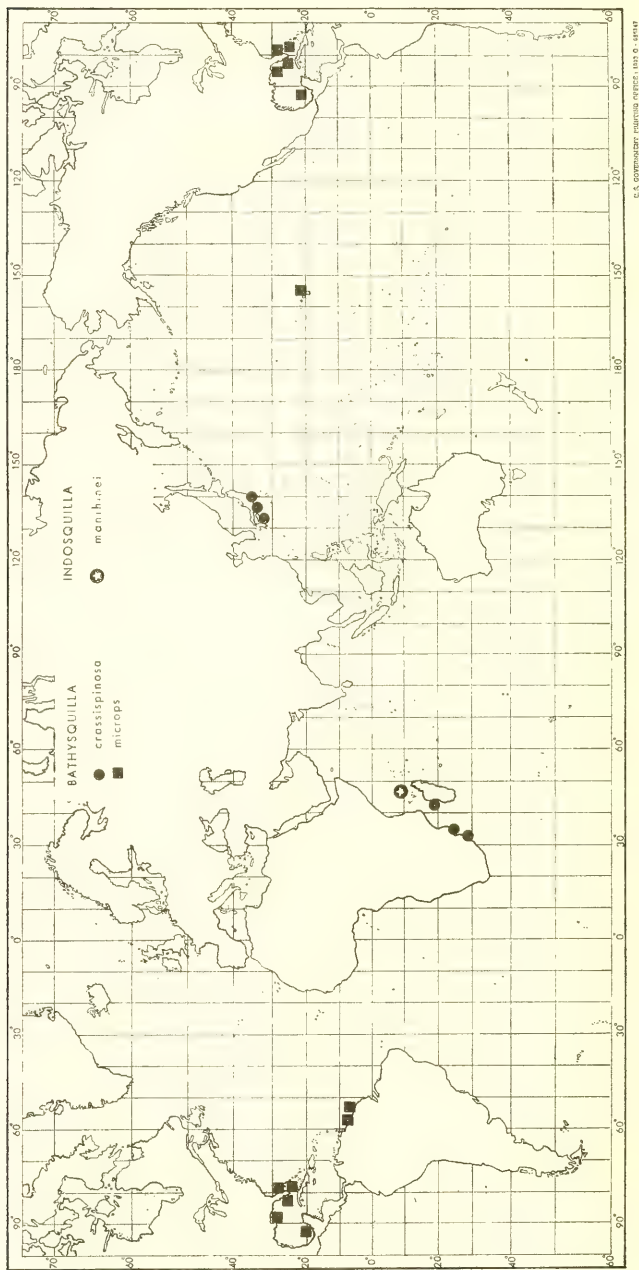


FIG. 2. Known distribution of bathysquillids.

The propodal index for five female *B. microps* (TL 173–220 m) ranges from 074–078; it is 074 in the female from Hawaii. Propodal indices of males of *B. microps* from the Atlantic (TL 68–255 mm) range from 074 to 092, the higher indices being found in the smaller specimens. The female from Hawaii has 2–3 proximal movable spines and 12–13 fixed spines on the opposable margin of the propodus of the claw. In Atlantic specimens, there are 2 movable proximal spines and 11–15 fixed spines; of 20 claws examined, 16 were armed with 13–14 teeth. The dactylus of the claw is armed with 13–15 teeth in Atlantic specimens, 14 in the female from Hawaii.

There are 7–8 movable spines on the proximal segment of the uropod in Atlantic specimens, 6 in the female from Hawaii.

Bathysquilla microps may be a slightly smaller species than *B. crassispinosa* which attains a total length of almost 300 mm. Males of *B. microps* have total lengths of 68–255 mm, and females ranging from 44.5 to 220 mm are known.

The color of the female specimen from Hawaii is similar to that of Atlantic specimens, based on photographs by J. E. Randall, Bernice P. Bishop Museum, D. Opresko, University of Miami, and B. Rohr, NMFS. On the Hawaiian specimen the anterior part of the body, from about the level of the antennae and including the eyes, is white; the rostral plate, like the carapace, is pink. The proximal portion of the propodus of the claw is white, the distal portion is pink, and the dactylus is orange. The proximal half of the walking legs is whitish, the distal part is pink. The remainder of the body is pink with orange carinae on the posterior portion of the body. Atlantic specimens show a similar pattern, but specimens have been taken in two color phases, red and orange.

Of the more than 300 shrimp trawl stations effected in the Hawaiian Islands by NMFS during the period 1967–72, the *Bathysquilla* capture occurred at the deepest successful station. Of the total of 300 stations, about 55 were in the 300–800 m depth range. Thus, it would appear that the minimum depth inhabited by *Bathysquilla* in the Hawaiian Island is about 750 m. At this depth the bottom temperature is approximately 5° C. An account of the recent NMFS surveys and the general ichthyological results are given by Struhsaker (1973).

Taxa of fishes associated with the Hawaiian capture of *Bathysquilla* were: sharks (*Apristurus*, *Etmopterus*); the eel families Congridae and Nettastomatidae; Halosauridae; Neoscopelidae; Ogocephalidae; Ophidioidei; Macrouridae (*Hymenocephalus*, *Malacocephalus*, *Matacocephalus*, *Nezumia*, *Trachonurus*, *Ventrifossa*); Cynoglossidae. The ophidioid fishes represent a species previously recorded only from the western Pacific and the Indian Ocean (Cohen, 1974). Also taken in the haul were three or four species of pandalid shrimps and 25 kg of discarded military ordnance.

During the 1902 expedition to the Hawaiian Islands of the U.S. Fish Commission steamer ALBATROSS, no specimens of *Bathysquilla* were

taken. Of the 257 beam trawl stations occupied during that expedition, 88 were in the 700–2800 m depth range. Bigelow (1931) reported on the stomatopods collected during that expedition and recorded only three species which occurred on the upper slope: *Echinosquilla guerinii* (White) in 55–335 m, *Odontodactylus brevisrostris* (Miers) in 55–439 m, and *O. hawaiiensis* Manning (as *O. japonicus*) in 110–278 m. Townsley (1953) recorded *E. guerinii* from depths of 92–220 m; all of the other stomatopods reported by Townsley from Hawaii were taken in comparatively shallower water.

Distribution (Fig. 2): Western Atlantic, from localities near Florida, in the Gulf of Mexico, and off northern South America, in depths between 604 and 1281 m, and off Maui, Hawaiian Islands in 731–786 m. Records include: BAHAMAS: Santaren Channel (24°24'N, 80°00'W), 732–860 m (Bullis and Thompson, 1965; Manning, 1969a).—FLORIDA: Off Cape Canaveral (28°03'N, 78°44'W), 915–952 m, and southeast of Tortugas (24°11'N, 83°21.5'W), 732 m (Manning, 1961, 1969a; Bullis and Thompson, 1965); south of Panama City (28°12'N, 86°09'W), 723 m.—MEXICO: Bahía de Campeche (21°31'N, 96°46'W), 1281 m.—SURINAM: 07°49'N, 54°22'W, 732 m; 07°47'N, 54°05'W, 769 m; 07°53'N, 54°04'W, 681–732 m.—FRENCH GUIANA: 07°37'N, 53°32'W, 723 m; 07°35'N, 53°32'W, 604–769 m; 07°32'N, 53°22'W, 641–659 m; 07°18'N, 52°59'W, 668–705 m; 07°06'N, 52°44'W, 668 m.—HAWAII: Off Maui (21°04'N, 156°09'W), 731–786 m.

GENERAL DISCUSSION

The discovery of a population in Hawaii of a species previously known from the western Atlantic raises many interesting questions, none of which can be answered with our current state of knowledge. Since bathysquillids represent an old stomatopod stock (see below), it seems likely that the Hawaiian and American populations are relicts of a more widely distributed species, but that the Atlantic populations colonized the Pacific or that the reverse occurred cannot be ruled out. It seems likely that two distinct populations now occur in the two areas, for gene flow between deepwater benthic populations in the western Atlantic and the central Pacific must be minimal, but if genetic differences exist they are not strongly reflected in morphological features. Too, geographically intermediate populations may well exist; the fauna of the upper slope is not that well known in most areas of the world.

Several species or species groups of slope fishes exhibit distributions similar to that of *B. microps*. The macrourid *Hymenocephalus aterrimus* is known only from the tropical western Atlantic and Hawaii in depths of 450–900 m. Marshall and Iwamoto (1973) state that there are virtually no differences between the populations in the two oceans except for a tendency for a slightly greater interorbital width in the Hawaiian specimens. They did not feel that subspecific or other recognition of the populations were required. Iwamoto (1974) recently described a new

subgenus and species of macrourid presently known only from the Gulf of Mexico, the Caribbean (732–1062 m), and the Hawaiian Islands (623–705 m). He apparently did not find any morphological differences in the two populations of *Nezumia* (*Kuronezumia*) *bubonis*. This subgenus also comprises a second species which occurs in the South China Sea (Iwamoto, 1974).

The plectognath fish genus *Hollardia* is represented in the tropical western Atlantic by *H. meadi* (Bahamas, Cuba, and Barbados: 135–450 m) and *H. hollardi* (Bermuda, Florida Keys, Gulf of Mexico, Caribbean: 225–915 m). Tyler (1968), in describing *H. goslinei* from Hawaiian waters (365 m), states that it and *H. hollardi* are closely related and have differentiated along the same lines in several important respects, while *H. meadi* differentiated less from the ancestral type, remaining more generalized than the other two species. He also discussed the peculiar distribution of the genus and speculated that the migration of the hollardiins into what is now the tropical western Atlantic must have been eastward through the Pacific with *goslinei* being the only presently known Pacific remnant with the extinction of eastern Pacific populations after the reemergence of Central America.

Finally, the Hawaiian endemic bothid flatfish *Chascanopsetta prorigera* was recently reported from the central western Atlantic by Gutherz (1967) on the basis of a still unpublished manuscript. Preliminary comparison of material from the two regions indicates to us that the western Atlantic population deserves recognition as a distinct species. However, these two forms are very close morphologically, and together constitute a distinctive group within the genus.

Such broad distributional patterns are generally rare within the stomatopods. Of approximately 300 species now recognized, only one, *Heterosquilla mccullochae* (Schmitt), can be considered to be pantropical, occurring in the eastern Pacific, the western Atlantic, and the Indo-West-Pacific regions. Five other species occur in both the Atlantic and the Indo-West-Pacific region but not in the eastern Pacific. Broad horizontal distribution patterns also appear to be rare, in general, in inhabitants of the upper slope (Ekman, 1953; Briggs, 1974).

Briggs (1974:435) has pointed out that "many ancient, phylogenetic relicts have accumulated in the slope habitat," and documented this with material recently reported in the literature on a variety of animal groups. The bathysquillids also represent one of these groups, an old stomatopod stock that occurs on the upper slope. The stomatopods are not well represented in the fossil record (Holthuis and Manning, 1969), and there is little evidence to indicate what are old or primitive characters in the group. However, the primary distinction between the single fossil family, Sculdidae, and the four recent families, is the presence of an unsegmented exopod in the sculdids. As Ingle and Merrett (1971) noted, one of the characteristics of *Indosquilla manihinei* is its uropodal exopod, with the distal segment indistinctly sutured rather than distinctly

articulated as in all other recent stomatopods. It seems likely that the bathysquillids do represent an ancient stomatopod stock.

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PROCEEDINGS
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AN ANALYSIS OF *PEROMYSCUS DIFFICILIS* FROM
 THE MEXICAN-UNITED STATES BOUNDARY AREA

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In April of 1964 and 1969 Woodrow W. Goodpaster, collecting for the Museum of Natural History, University of Illinois, obtained 15 specimens of *Peromyscus* of uncertain taxonomic status from the Franklin Mountains, El Paso County, Texas. Numerous mammalogists examined these 15 specimens, offered suggestions for possible affinities, but never were certain enough to assign specific identification. Subsequent examination of these and additional specimens, some of which were from the Franklin Mountains, proves that they are *Peromyscus difficilis*, that this species occurs in mountainous areas near the Rio Grande River, and that they are referable to a distinct subspecies. This subspecies is called *Peromyscus difficilis penicillatus* Mearns (*Peromyscus boylii penicillatus* of Mearns).

To establish a means of species recognition, comparative studies using 20 skin and skull features were made of samples of *P. polius*, *P. boylii rowleyi*, *P. pectoralis laceianus*, *P. truei truei*, *P. truei comanche*, *P. attwateri*, and *P. difficilis*. In addition cranial and external morphology, along with cytological evidence was used in studying intrapopulation and interpopulation variation in five subspecies of *P. difficilis*: *P. d. nasutus*, *P. d. griseus*, *P. d. penicillatus*, *P. d. difficilis*, and *P. d. petricola*.

METHODS

Over 1000 specimens representing six species of the genus *Peromyscus* were studied. External measurements were taken

from the specimen label and 15 cranial measurements were taken by me with a dial caliper and recorded in millimeters. Head and body length was calculated. The 15 cranial measurements were: greatest skull length, basilar length, breadth of braincase, mastoid breadth (distance between lateral expansions of mastoid processes), zygomatic breadth (greatest distance between the outer borders of the zygomatic arches), bullae breadth (least distance between the ventral margins of the bony external auditory meatuses), bulla length (least distance from the antero-ventral margin of the bony external auditory meatus to the point of exit of the eustachian tube from the bony auditory bulla), least interorbital constriction, nasal length, palatal length, palatal foramen length, diastema length, post-palatal length, maxillary tooththrow length (actual length of the molar tooththrow measured near the crown of the teeth), and skull depth (taken as described by Hooper, 1952:10). All other measurements were taken as illustrated by Hoffmeister (1951:28).

Ageing of specimens was based on wear of the upper molar tooththrow. Ageing is discussed in "Nongeographic Variation."

SPECIES RECOGNITION

Specimens of *P. d. penicillatus* from the Franklin Mountains, El Paso County, Texas, are like specimens of other subspecies of *P. difficilis* in having a tail usually longer than the head and body, large hind feet, ears of moderate length, a broad braincase, long maxillary tooththrow, and moderately inflated auditory bullae.

P. difficilis penicillatus differs in coloration from *P. boylii rowleyi* in having uniform pale gray upper parts with the sides and top of the head a noticeable lighter gray than the gray body, rather than ochraceous sides and brownish upper parts and head; externally in a longer tail, hind feet, and ears; cranially in a broader braincase, greater mastoidal breadth, more inflated auditory bullae, and shorter nasals; chromosomally four pairs of large biarmed autosomes rather than one pair of large biarmed autosomes. See Figure 1 for comparisons of maxillary tooththrow length vs. bullae breadth.

P. d. penicillatus differs from *P. pectoralis laceianus* ex-

ternally in having a longer tail, hind feet, and ears; cranially in a broader braincase, greater mastoidal breadth, more inflated auditory bullae, longer maxillary tooththrow, and greater skull depth. See Figure 1 for comparisons of maxillary tooththrow length vs. bullae breadth.

P. d. penicillatus differs from *P. attwateri* externally in having a shorter head and body and shorter hind feet; cranially in a shorter skull, smaller zygomatic breadth, smaller interorbital constriction, shorter nasals, and shorter diastema; chromosomally four pairs of large biarmed autosomes rather than three pairs of large biarmed autosomes.

P. d. penicillatus differs from *P. truei truei* and *P. truei comanche* externally in having a longer tail (much shorter in *P. t. truei* and slightly shorter in *P. t. comanche*), and shorter ears; cranially in less inflated auditory bullae, longer palate, and longer maxillary tooththrow; chromosomally four pairs of large biarmed autosomes rather than five pairs of large biarmed autosomes. See Figure 1 for comparisons of maxillary tooththrow length vs. bullae breadth. *P. t. comanche*, considered a distinct species by Johnson and Packard (1974), is here considered a subspecies of *P. truei* following Schmidly (1973a).

P. d. penicillatus differs from *P. polius* externally in having a shorter head and body, and shorter hind feet; cranially in a shorter skull, narrower braincase, smaller mastoidal breadth, smaller zygomatic breadth, shorter nasal, shorter diastema, and shorter maxillary tooththrow.

HABITAT

During the progress of this study, specimens of *P. difficilis* were taken by me at 14 different localities representing 10 counties in Arizona, New Mexico, Oklahoma, and Texas. Specimens were taken as low as 4700 ft, Franklin Mountains, Texas, and as high as 8200 ft, Chiricahua Mountains, Arizona.

The parameter in common to all areas where *P. difficilis* was collected was the "rockiness" of the habitat. Adult individuals were invariably taken in rocky situations such as lava beds, talus slopes, areas of numerous jumbled rocks, or

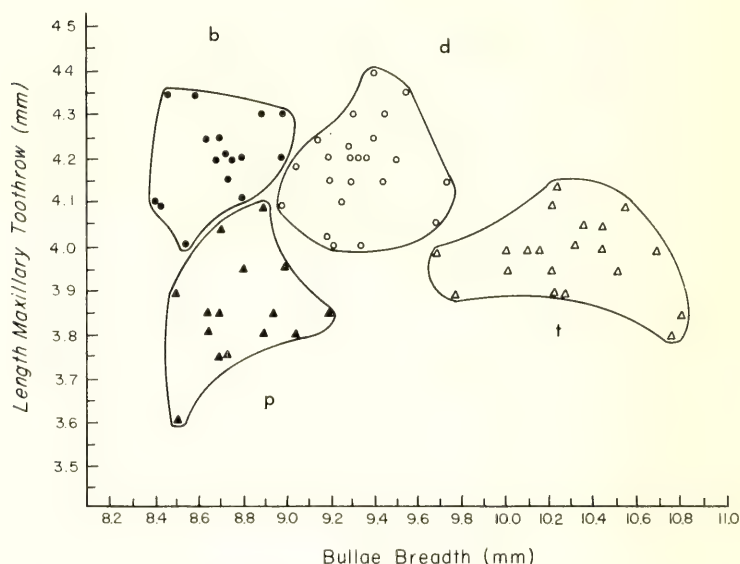


FIG. 1. Individual specimens of four species of *Peromyscus* plotted according to bullae breadth vs. maxillary tooththrow length, on a scatter diagram. *P. b. rowleyi* (indicated by solid circles on the scattergram), Franklin Mtns., Texas; *P. d. penicillatus*, Franklin Mtns., Texas, open circles; *P. p. lacianus*, vic. Carlsbad, Eddy County, New Mexico, closed triangles; *P. t. truei*, vic. Winslow, Navajo County, Arizona, open triangles.

any other extensively rocky area having many fissures. Specimens taken outside such areas were usually immature individuals, probably driven into submarginal habitat by population pressure. In these rocky areas where *P. difficilis* was abundant, *P. boylii* was absent. *P. boylii* was abundant in adjacent areas of lesser rock density, and therefore more vegetated. It then seems that niche segregation of these two species is largely determined by the density of the rocks and the amount of interspace within those rocks.

NONGEOGRAPHIC VARIATION

Age variation: Analyses were done only on those individuals in adult pelage which had considerable wear on all



FIG. 2. Karyogram of *P. difficilis penicillatus*, female, UI 50529, from McKelligan Canyon, Franklin Mountains, El Paso County, Texas.

lingual cusps of all upper molars with at least moderate wear on all labial cusps.

Individual variation: Coefficients of variation for 20 skin and skull characters taken from a sample of 35 adult specimens from the Franklin Mountains, El Paso County, Texas, indicate, that all characters exhibited normal variability (Table 1). External measurements were more variable than cranial measurements. Individual variation of the Franklin Mountains population of *P. difficilis* was in agreement with reported variation in other species of *Peromyscus* (Hoffmeister, 1951, Schmidly, 1972, 1973b).

Secondary sexual variation: Of the 20 characters given in Table 1, ear length was sexually dimorphic at the .05 level; greatest skull length, and basilar length were sexually dimorphic at the .02 level; mastoidal breadth, and post-palatal length were sexually dimorphic at the .01 level. The 15 other characters were not significantly sexually dimorphic. Males

TABLE 1. Secondary sexual dimorphism and individual variation in *P. difficilis penicillatus* from the Franklin Mountains, El Paso County, Texas. (* denotes significant difference.)

	Females				Males				t-test
	N	\bar{X}	S.D.	C.V.	N	\bar{X}	S.D.	C.V.	
Total length	15	206.73	7.13	3.45	20	205.05	9.99	4.88	0.55
Tail length	15	112.27	4.80	4.28	20	111.50	8.22	7.37	0.32
Body length	15	94.47	4.37	4.63	20	93.55	2.63	2.81	0.77
Hind foot length	15	23.60	0.91	3.86	20	23.80	0.62	2.61	0.77
Ear length	14	20.57	0.65	3.16	20	20.00	0.73	3.65	2.34*
Greatest skull length	15	27.99	0.58	2.07	19	27.53	0.50	1.82	2.48*
Basilar length	15	21.14	0.50	2.37	19	20.74	0.41	1.98	2.56*
Breadth of braincase	15	12.91	0.24	1.86	20	12.81	0.25	1.95	1.19
Mastoid breadth	15	12.18	0.21	1.72	19	11.98	0.14	1.17	3.33*
Zygomatic breadth	15	13.79	0.38	2.76	19	13.62	0.18	1.32	1.73
Bullae breadth	15	9.32	0.19	2.04	18	9.26	0.20	2.16	0.88
Bulla length	15	3.54	0.13	3.67	19	3.48	0.13	3.74	1.34
Interorbital constriction	15	4.41	0.12	2.72	20	4.45	0.10	2.25	1.08
Nasal length	15	10.48	0.26	2.48	20	10.32	0.30	2.91	1.65
Palatal length	15	4.37	0.18	4.12	20	4.37	0.18	4.12	0.01
Palatal foramen length	15	5.78	0.23	3.98	20	5.66	0.16	2.83	1.82
Diastema length	15	7.03	0.20	2.84	20	6.90	0.21	3.04	1.85
Post-palatal length	15	9.83	0.27	2.75	19	9.61	0.16	1.66	2.96*
Maxillary toothrow length	15	4.17	0.12	2.88	20	4.14	0.09	2.17	0.85
Skull depth	15	10.03	0.23	2.29	18	10.11	0.27	2.67	0.82

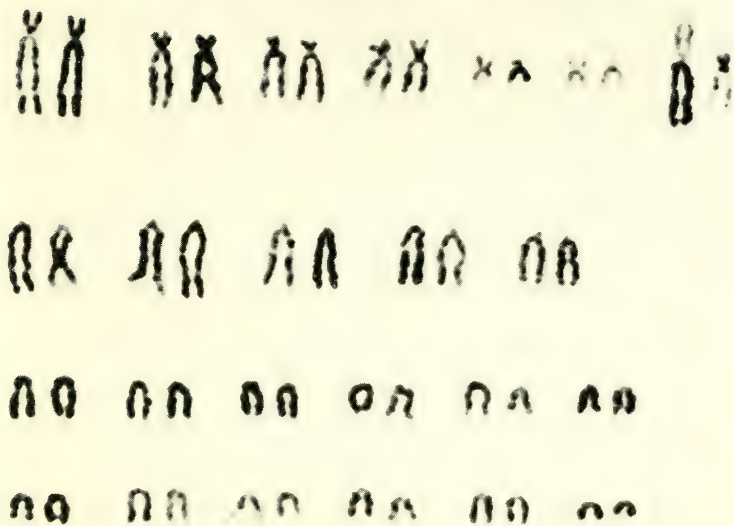


FIG. 3. Karyogram of *P. difficilis griseus*, male, UI 48397, from the Carrizozo lava beds, Lincoln County, New Mexico.

and females of a sample were combined in analyzing geographic variation.

GEOGRAPHIC VARIATION

Chromosomal evidence: Species of the genus *Peromyscus* are consistent in having karyotypes of 48 chromosomes. The autosomal complement usually consists of several pairs of large biarmed chromosomes, several pairs of small biarmed chromosomes, and a number of acrocentric chromosomes.

Hsu and Arrighi (1968) described the karyotype of *P. difficilis* as being polymorphic. Karyotypes of *P. d. nasutus* from Fort Collins, Colorado, contained four pairs of large biarmed autosomes and specimens of *P. d. saxicola* from Jacala, Hidalgo, Mexico, contained three pairs of large biarmed autosomes. Lee, et al. (1972) also described karyotypes of *P. d. nasutus* from Colorado and northwestern New Mexico with four pairs of large biarmed autosomes.

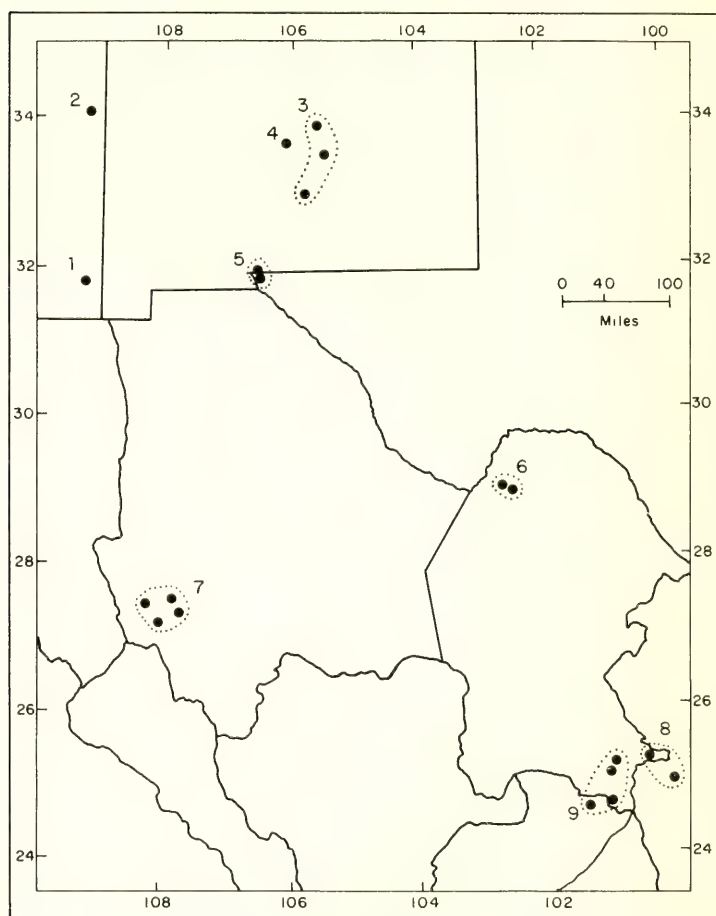


FIG. 4. Collecting localities of *P. difficilis* are represented by circles. Adjacent localities were usually grouped to increase sample size. Sample locality 1, Chiricahua Mountains, Arizona; 2, Springerville, Arizona; 3, Capitan, Jicarilla, and Sacramento mountains, New Mexico; 4, Carrizozo lava beds, Lincoln County, New Mexico; 5, Franklin Mountains, El Paso County, Texas; 6, Sierra del Carmen Mountains, Coahuila, Mexico; 7, vicinity Creel, Chihuahua, Mexico; 8, vicinity Sierra Guadalupe, Coahuila, and Cerra Potosi, Nuevo Leon, Mexico; 9, vicinity Bella Union, Carneros, Sierra Encarnacion, Coahuila; and Concepcion del Oro, Zacatecas.

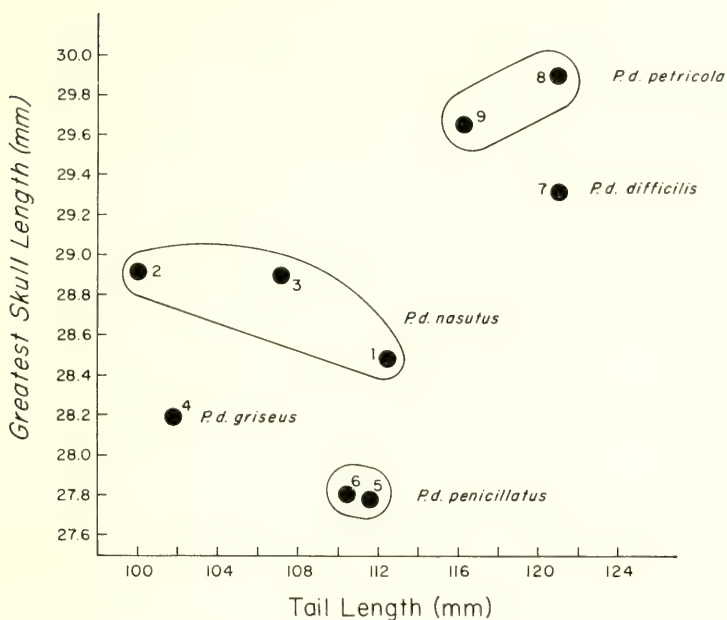


FIG. 5. Scattergram plotting mean tail length versus mean skull length in samples of *P. difficilis*. Numbers within the figure correspond to the locality numbers of Fig. 4 and Table 2.

Specimens representing two subspecies of *P. difficilis* were collected and karyotyped: *P. d. penicillatus* (Fig. 2) from the Franklin Mountains, El Paso County, Texas, and *P. d. griseus* (Fig. 3) from the lava beds near Carrizozo, Lincoln County, New Mexico. Karyotypes of both subspecies did not differ from karyotypes of *P. d. nasutus* in having four pairs of large biarmed autosomes. A series of karyotypes from both subspecies may establish slight morphological differences in the X chromosomes.

Morphological evidence: Eleven characters were selected and geographic variation was assessed to ascertain the affinities of each population to the Franklin Mountains' population of *P. difficilis*. In plotting collecting localities (Fig. 4) some localities of close proximity were grouped to increase sample size.

TABLE 2. Measurements of 9 samples of *P. difficilis*. Given for each character are: mean, 1 standard deviation each side of the mean, coefficient of variation, and sample size, respectively. Locality numbers, given in parentheses, correspond to locality numbers of Figure 4.

Head and body	Tail	Hind foot	Ear	Greatest l. skull	Breadth braincase	Mastoidal breadth	Bullae breadth	Nasal length	Diastema length	Toothrow length
(1) <i>P. d. nasutus</i> , Chiricahua Mountains, Cochise Co., Arizona										
97.2	112.5	23.91	21.74	28.44	13.22	12.34	8.84	10.71	7.43	4.35
4.49	7.24	0.54	1.30	0.79	0.22	0.22	0.25	0.37	0.36	0.10
4.62	6.44	2.26	5.98	2.78	1.66	1.78	2.83	3.45	4.85	2.30
17	16	17	17	17	17	17	17	17	17	17
(2) <i>P. d. nasutus</i> , vic. Springerville, Apache Co., Arizona										
100.3	100.0	23.42	21.96	28.91	13.24	12.31	9.47	11.37	7.50	4.26
3.69	4.19	0.76	0.91	0.47	0.20	0.20	0.17	0.31	0.19	0.12
3.68	4.19	3.26	4.16	1.61	1.52	1.63	1.81	2.70	2.53	2.74
12	11	12	12	14	14	14	13	14	14	14
(3) <i>P. d. nasutus</i> , Capitan, Sacramento, and Jicarilla mountains, New Mexico										
99.7	107.5	22.86	22.29	28.89	13.16	12.45	9.35	11.23	7.39	4.11
5.52	5.09	0.78	1.60	0.43	0.25	0.21	0.30	0.36	0.22	0.15
5.54	4.73	3.41	7.18	1.49	1.90	1.69	3.21	3.21	2.98	4.87
20	21	21	7	19	20	19	19	20	18	20
(4) <i>P. d. griseus</i> , Carrizozo lava beds, Lincoln Co., New Mexico										
94.6	101.9	23.07	21.34	28.19	12.91	12.18	9.30	11.12	7.25	4.16
3.93	5.13	0.69	1.12	0.50	0.26	0.24	0.27	0.30	0.24	0.09
4.15	5.03	2.55	5.25	1.78	1.98	1.97	2.88	2.71	3.27	2.11
44	44	44	44	43	44	44	42	43	44	44
(5) <i>P. d. penicillatus</i> , Franklin Mountains, Texas and New Mexico										
94.2	111.7	23.76	20.24	27.74	12.85	12.07	9.30	10.40	6.96	4.16
3.28	6.97	0.70	0.74	0.59	0.25	0.20	0.19	0.29	0.22	0.11
3.48	6.24	2.94	3.66	2.11	1.91	1.69	2.01	2.74	3.13	2.57
34	34	34	34	33	34	33	32	34	34	34
(6) <i>P. d. penicillatus</i> , Sierra del Carmen, Coahuila										
91.0	110.5	22.42	21.33	27.80	12.96	11.90	8.92	10.76	7.18	4.20
10.9	7.98	0.28		0.52	0.24	0.16	0.17	0.26	0.17	0.10
12.0	7.23	2.37		1.87	1.81	1.38	1.91	2.56	2.42	2.38
12	12	12	3	8	9	8	8	12	12	12

TABLE 2. (cont.)

Head and body	Tail	Hind foot	Ear	Greatest l. skull	Breadth braincase	Mastoidal breadth	Bullae breadth	Nasal length	Diastema length	Toothrow length
(7) <i>P. d. difficilis</i> , vic. Creel, Chihuahua, Mexico										
97.6	121.1	25.00	26.03	29.30	13.28	12.47	9.22	11.70	7.60	4.36
5.79	8.29	0.96	1.94	0.42	0.23	0.20	0.24	0.33	0.22	0.11
5.93	6.85	3.82	7.45	1.43	1.75	1.61	2.63	2.80	2.87	2.61
19	19	19	19	20	19	19	19	20	20	18
(8) <i>P. d. petricola</i> , vic. Sierra Guadalupe, Coah., Cerra Potosi, Nuevo Leon										
104.9	121.0	24.71	23.17	29.89	13.40	12.98	9.70	11.63	7.42	4.45
8.32	7.03	1.07	1.60	0.49	0.20	0.19	0.25	0.22	0.17	0.17
7.93	5.81	4.33	6.91	1.64	1.49	1.46	2.58	2.32	2.29	3.82
14	14	14	6	12	13	13	11	12	14	14
(9) <i>P. d. petricola</i> , Concepcion del Oro, Zac., vic. Sierra Encarnacion, Coah.										
103.8	116.3	24.76	22.13	29.65	13.32	12.86	9.72	11.66	7.63	4.50
7.50	10.55	0.81	0.64	0.50	0.24	0.25	0.24	0.23	0.14	0.20
7.22	9.07	3.27	2.89	1.69	1.80	1.94	2.47	1.97	1.83	4.44
17	17	17	8	16	17	16	16	17	17	17

Variation was not uniform, with areas of differentiation corresponding to large desert basins or areas of low relief. See Table 2 for measurements of all samples of *P. difficilis*. Samples from the Chiricahua Mountains, Arizona (sample 1 of Figs. 4, 5, and Table 2); Springerville, Arizona (sample 2); and from the Capitan, Sacramento, and Jicarilla mountains, New Mexico (pooled as sample 3); agree with each other and differ from the Franklin Mountains' population of *P. difficilis* in having an overall larger skull, broader braincase, greater mastoidal breadth, longer diastema, and in being darker in coloration. The Chiricahua Mountains' population of *P. difficilis* are unique as a sample in having a longer tail in combination with smaller auditory bullae but are here referred with Springerville and Capitan samples.

Sample 4 from the Carrizozo lava beds, Lincoln County, New Mexico, differ from the Franklin Mountains' population

of *P. difficilis* in having a shorter tail, longer ears, a longer diastema, longer nasals, and in being much darker in coloration.

Sample 7 from the vicinity of Creel, Chihuahua, Mexico, differs from the Franklin Mountains population in having a longer tail, longer hind feet, and much longer ears, an overall larger skull, actually smaller auditory bullae, and in being darker in coloration.

Samples 8 and 9 from northern Zacatecas, southern Coahuila, and west-central Nuevo Leon, Mexico, differ from the Franklin Mountains' population of *P. difficilis* in having a longer tail, longer hind feet, longer ears, a much larger skull with especially larger mastoidal breadth, greatly inflated auditory bullae, and in being darker in coloration.

Sample 6 from the Sierra del Carmen Mountains, Coahuila, are here referred to the subspecies *P. d. penicillatus*. Only a small sample is available, but the specimens at hand compare with the Franklin Mountains' population in coloration, all external measurements, and in all cranial measurements, except the specimens from the Sierra del Carmen Mountains have the diastema averaging slightly longer and noticeably smaller auditory bullae than the Franklin Mountains' population of *P. d. penicillatus*.

Peromyscus difficilis penicillatus Mearns

Peromyscus boylii penicillatus E. A. Mearns, 1896, Preliminary diagnoses of new mammals from the Mexican border of the United States, p. 2, May 25 (preprint of Proc. U. S. Nat. Mus., 19:139, December 21, 1896).

Peromyscus boylii rowleyi, W. H. Osgood, 1909, A revision of the mice of the American genus *Peromyscus*. N. Amer. Fauna, 28:145, April 17.

Type locality: Foothills of the Franklin Mountains, near El Paso, El Paso County, Texas. Type, skin and skull, USNM 20034/35426. Holotype examined.

Range: Known from the Franklin Mountains (extending from El County, New Mexico), Sierra del Carmen Mountains, northern Coahuila, Mexico, and a single specimen, cat. no. 21129/37194, U. S. Nat. Mus., collected by E. A. Mearns from Dog Springs, Grant County (now Hidalgo County), New Mexico. Other populations might exist on other isolated mountain ranges in northern Coahuila, western

Texas, southern New Mexico, and northwestern Chihuahua. Collecting at Dog Springs in the summer of 1974 produced only *Peromyscus boylii* and *Peromyscus eremicus*.

Diagnosis: A subspecies of *P. difficilis* recognized externally by its uniform gray upper parts, white underparts, and long penicillate tail. Paso, El Paso County, Texas, north for 10 miles into Doña Ana. The sides and top of the head is noticeably lighter gray than the gray body. Cranially the smallest subspecies of *P. difficilis* with short nasals and short diastema. Karyotype of four pairs of large biarmed, two pairs of small biarmed, and 17 pairs of acrocentric autosomes.

Comparisons: *Peromyscus difficilis penicillatus* differs from *P. difficilis griseus*, *P. d. nasutus*, *P. d. difficilis*, and *P. d. petricola*, in having an exceedingly short skull (reflected in having shorter nasals and shorter post-palatal length), and in its light gray head and body coloration rather than a brown to brownish-black coloration. It differs from *P. d. nasutus* and *P. d. griseus* in having a relatively long tail (119% head and body length rather than 98 to 109%), and differs from *P. d. petricola* in having shorter ears, smaller auditory bullae, and smaller mastoidal breadth. See Figure 5 for comparisons.

Remarks: Osgood (1909:145) in synonymizing *P. d. penicillatus* (then *P. boylii penicillatus*) with *P. boylii rowleyi* says that "the type of *penicillatus* is an abnormally pale individual, but a series from the Franklin Mountains near the type locality does not differ from typical *rowleyi*." In actuality the type of *P. boylii penicillatus* that Osgood examined was a specimen of *P. difficilis* and the series that he talks about were *P. boylii*, which also occur in the Franklin Mountains, and which are referable to *P. b. rowleyi*.

Specimens examined: Total 175 from: TEXAS. EL PASO CO.: 3½ mi W Fort Bliss, Trans-Mountain Road, 5 (UI); McKelligan Canyon Park, 107 (UI); Head McKelligan Canyon, 4700 ft, 10 (KU). NEW MEXICO. DOÑA ANA CO.: 16 mi N El Paso, 10 (UI); 15 mi N El Paso, 21 (UI); 15 mi N El Paso, 5 mi SE junction I-10 and HWG 404, 4 (UI); HIDALGO CO.: Dog Springs, 1 (USNM). COAHUILA. 15 mi S, 25 mi E Bouquillas, 7300 ft, 3 (NTSU); Sierra del Carmen, Campo Madera, 8000 ft, 10 (9 USNM, 1 DMNH); Sierra del Carmen, Oso Cañon, 3 (DMNH); Sierra del Carmen, Botellas Cañon, 1 (DMNH).

For all other specimens of *P. difficilis*, examined by me, the taxonomy followed is that given by Hoffmeister and de la Torre (1961).

Peromyscus difficilis griseus Benson

Specimens examined: Total 185. NEW MEXICO. LINCOLN CO.: 6½ mi W, 5 mi N Carrizozo, 9 (UI); 5 mi W, 5 mi N Carrizozo, 21 (UI); 5 mi N, 4.75 mi W Carrizozo, 25 (UI); 4¼ mi N, 3½ mi W Carrizozo, 25 (UI); 3 mi N, 2.75 mi W Carrizozo, 70 (UI); 3 mi W Carrizozo, 2 (UI); 3½ mi W, 2 mi N Carrizozo, 33 (UI).

Peromyscus difficilis nasutus (J. A. Allen)

Specimens examined: Total 259. NEW MEXICO. SIERRA Co.: San Andres Mtns., N slope Salinas Peak, 6000 ft, 4 (USNM); San Andres Mtns., Bear Canyon, 2 (USNM); San Andres Mtns., N slope Salinas Peak, 5000 ft, 3 (USNM). LINCOLN Co.: Capitan Mountains, 24 (USNM); Corona, 1 (USNM); Jicarilla Mountains, 15 (USNM). OTERO Co.: $\frac{1}{2}$ mi W High Rolls, 13 (6 UI, 7 JD); 12 mi E Alamo-gordo, 1 (JD); Sacramento Mtns., 1 mi W High Rolls, 2 (UTEP); Russian Canyon, Sacramento Mtns., 5 mi S, $2\frac{1}{2}$ mi E Cloudercroft, 1 (UTEP); Doña Ana Co.: 35 mi NE Las Cruces, San Andres Canyon, San Andres Mtns., 5600 ft, in tunnel of lead mine, 1 (USNM). EDDY Co.: Slaughter Canyon, 4.75 mi S, 11 mi W White City, 1 (UI); 26 mi W, 10 mi S Carlsbad, 1 (ENMU). ARIZONA. APACHE Co.: Springerville, 2 (USNM); 4 mi E Springerville, 60 (UI); $4\frac{1}{2}$ mi ESE Springerville, 44 (UI); 3 mi SE Springerville, 11 (USNM); $4\frac{1}{2}$ mi SSE Springerville, 33 (UI). COCHISE Co.: $1\frac{1}{4}$ mi E Fly's Peak, Greenhouse Canyon, Chiricahua Mtns., 7500 ft, 15 (UI); Fly's Peak, Chiricahua Mtns., 10 (UI); $\frac{1}{2}$ mi E Buena Vista Peak, Chiricahua Mtns., 8100 ft, 2 (UI); 7 mi W Portal, 1 (JD); 1 mi NW Research Station, Chiricahua Mtns., 1 (UI); 1 mi SW Portal, 7 (UI); 1 mi up Cave Creek from Portal, 1 (UI). TEXAS. CULBERSON Co.: McKittrick Canyon, 7800 ft, 1 (USNM); 2 mi E Pine Springs, 2 (UI).

Peromyscus difficilis difficilis (J. A. Allen)

Specimens examined: Total 42 from: CHIHUAHUA. 15 mi S, 6 mi E Creel, 7300 ft, 24 (KU); Divisadero, 16 mi S, 13 mi W Creel, 7500 ft, 14 (KU); N rim Barranca del Cobre, 23 mi S, $1\frac{1}{2}$ mi E Creel, 7200 ft, 3 (KU); Churo, 7200 ft, 1 (KU).

Peromyscus difficilis petricola Hoffmeister and de la Torre

Specimens examined: Total 66 from: COAHUILA. Sierra Encarnacion, 19 (USNM); Carneros, 2 (USNM); Sierra Guadalupe, 25 (USNM); 8 mi S Bella Union, HWY 57, 6 (UI). NUEVO LEON. Along road 1 mi NE microwave tower, E slope Cerra Potosi, 1 (USNM); .75 mi NE microwave tower, E slope Cerra Potosi, 1 (USNM); Rocks along road NE microwave tower, 9850 ft, E slope Cerra Potosi, 1 (USNM); Rock ledge, Cerra Potosi, 1 (USNM). ZACATECAS. 4 mi W Concepcion del Oro, 10 (UI).

CONCLUSIONS

Peromyscus difficilis from the Franklin Mountains of Texas and New Mexico and from northern Coahuila are referable to a distinct subspecies for which the name *Peromyscus boylii penicillatus* Mearns, 1896, is available. Analyses of various cranial, external, and chromosomal characters are presented to facilitate recognition of *P. difficilis penicillatus* from closely related species of *Peromyscus*. Methods are

discussed for differentiating *P. difficilis penicillatus* from geographically peripheral subspecies of *P. difficilis*: *P. d. griseus*, *P. d. difficilis*, *P. d. nasutus*, and *P. d. petricola*. The habitat preference of *P. difficilis* is described.

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PROCEEDINGS
OF THE
BIOLOGICAL SOCIETY OF WASHINGTONMORE ON EARTHWORM DISTRIBUTION IN
NORTH AMERICABY G. E. GATES¹*Tall Timbers Research Station
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The earthworm fauna of the United States has been much misunderstood both at home and abroad. Consideration of certain beliefs, rather commonly held in the United States, at least in the past, is the main purpose of the present contribution. Primarily involved is the Quaternary climate and the fact (Gates, 1970:9, No. 1) that all earthworms must have been exterminated, at the very least throughout the areas then covered with ice thousands of feet thick.

Subsequently, in America as also in Europe, the native earthworms actively followed the retreating glacial ice northward (Smith, 1912, who merely stated a rather generally accepted belief). Involved in any such northward migration theoretically there could have been included six genera in five families, three of which are solely American. Much more recently, European lumbricids supposedly replaced (in active competition?) native earthworms "as was described by Smith whose observations were supported by Goff, and has been commonly accepted" (Stebbins, 1962: 905). Of the six genera that could have been involved, Stebbins seems to have been concerned only with one, the acanthodrilid *Diplocardia*.

Past misunderstandings, as well as present misconceptions, require emphasis on the following: Native earthworms of any part of the world were unknown until well after European travels and settlements therein. Almost everywhere Europeans went, except in tropical lowlands and in arctic permafrost, earthworms from Europe eventually were recognized.

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For example, consider Smith's portion of central Illinois. Even as the first native American earthworm, *Diplocardia communis*, was being described, at least four European species, *Aporrectodea rosea* and *A. trapzoides* (if not also *A. turgida* and *A. tuberculata*), *Eisenia foetida* and *Octolasion tyrtaeum*, already had become so well domiciled as to be characterized as "frequent" to "abundant", though Garman (1888) only mentioned three of them. Also, the only agent known to be engaged in transporting earthworms on a large and continuous scale (for centuries if not millenia) is man.

Data for the report (Smith, 1928) that provided the basis for "the commonly accepted" belief mentioned by Stebbings were secured from study of a small area of glaciated Illinois centering around Champaign-Urbana. The worms were considered in three undefined classes:

1) "Woodland species", better characterized as litter feeders. They move about on the surface of the soil while searching for those concentrations of organic matter in which they usually abound. No change in woodland populations during the period involved, 1892-1927, was recognized. Only three species were mentioned (Idem, p. 349) as belonging to the group and two of them obviously are native; *Bimastos gieseleri* and *B. hempeli*. The third, now known as *Dendrodrilus rubidus*, has been found around the world in appropriate climates such as are furnished by South Africa, Australia, New Zealand, southern South America and various oceanic islands.

2) "Stream-bank species". Of those so regarded by Smith, two are better characterized as limiphagous or limicolous. One, the European *Eiseniella tetraedra* only very rarely, and the other, the American *Sparganophilus eiseni*, never is naturally found away from saturated mud. Other worms listed as stream bank forms really are geophagous or litter feeders. Some of the former have shown a tendency to aggregate at or near mildly contaminated sites such as soil near or under cow-manure pats. Some of the litter feeders do adapt to polluted habitats like those along the banks of the sewage-contaminated stream that was studied. Along that stream bank was made the only continuously recorded survey for any part of the Champaign-Urbana area. During 1922-1923, a graduate student dug from 11 sites along the bank 5,134 worms. Number of collections at a site varied from one to 12 but usually was more than three. Information was not provided as to how close to the polluted water the worms were dug nor as to the liability to flooding at each site during any part of the year. Few native forms were obtained, and these at only two of the sites, neither of which had previously been searched! The species were *D. communis* (2 specimens) and *D. singularis* (94 specimens). The latter native was not again mentioned although earlier it had been said to be "common" in upland regions of central Illinois (Smith, 1915: 556). Are we supposed to assume without supporting evidence that those natives formerly had been present at each of the other nine sites? The largest number of specimens to be listed (Smith,

1928: 332, Table 1) was of a geophagous form called *Helodrilus caliginosus trapezoides* (now known as *Aporrectodea trapezoides*) but which could have comprised at least two other species. Each one of the three is geophagous, as common if not more so away from stream banks, and better characterized by its feeding.

3) "Upland-soil species", better characterized also as geophagous because of their diet. Most of these do not ordinarily crawl about on the surface unless forced there during rains. *Lumbricus terrestris* may also sometimes be forced to the surface during rain but it alone feeds and copulates on the surface during the night when conditions are favorable to such activities. Although a number of species (including seven of those found at the stream bank sites) could have been considered here, the discussion was restricted to but two and then only with reference to individuals seen above ground during and after rain. Referring to one of the pair, the American *Diplocardia communis* Garman (1888), its author was quoted as follows: "Hundreds were seen in this locality, migrating during showers of rain." Migrating seems a poor word for worms that probably were forced out of their abode, many perhaps to die the next day, as often happens. The other species, the European *Lumbricus terrestris*, was first seen in the same area (but only after rain and when it already may have become fairly well established) "probably about 1896". Subsequently, the night crawler was thought to have become abundantly stocked (judged by observations after rainfall). Meanwhile, the native species decreased until on the last night of recording in March, 1927, only 19 specimens were seen in the streets bordering 24 city blocks. Nevertheless, Smith did state that the American worm still was abundant in 1927 in areas further to the east where the night crawler was rarely seen (after rain).

Geophagous earthworms do surface after the soil has been poisoned by dilute solutions of various chemicals, as is well known to those who must collect them without digging. Observations for more than 20 years at a single site in Bangor, Maine, indicate that any particular rain rarely, if ever, brings up each and every species known to be present. On the contrary, different rains produce different species on different occasions and in different percentages. So it can be suggested that the night crawler may have replaced the native *D. communis* in the lawns of the two Illinois cities for two reasons: First, because the soil-infiltrating, industrial poisons in the rain were more deleterious to the native than to the exotic form. Second, because the grass lawns of the cities may be more like the normal habitat for *L. terrestris* than for *D. communis* (cf. Harman, 1960: 66).

All species of the genus *Bimastos* are native to the southern states of this country. One, *B. longicinctus*, was common in soils and parkings of Urbana when first described in 1915 (Smith, 1915: 537). Another, *B. zeteki*, was said at the same time to be common in central Illinois. All species of that genus as well as most of two other American genera

were ignored by Smith in his discussion of the subject under consideration. Even in 1928, "replacement" of the native species in central Illinois was far from complete. How partial replacement may have been now seems to be indeterminable, in absence of information as to when natives of the three genera did reach central Illinois and how extensive their distribution was before man started bringing exotic species from all around the world to America after 1500 A.D. Certainly, Smith provided little basis for the "commonly accepted" replacements which Stebbings himself hesitated to accept. However, Stebbings' doubts seem to have been mostly about conditions west of the Mississippi River, a region with which this contribution is not concerned.

Smith did say (1928: 347), "The tendency is toward an increasing domination of European species, and a corresponding decrease in abundance of some indigenous forms." However, it probably would have been more accurate to end that sentence in some such way as "... in city lawns and along banks of a sewage polluted stream." Certainly, Smith did no more than suggest that a similar change might be under way in other parts of the state. Accordingly, parts of Stebbings' discussion are irrelevant, as they seem to be based on an unwarranted (even if widely held?) assumption that the replacements supposedly found by Smith involved much, if not most, of all states in a central part of the country. Furthermore, Smith did not take into consideration the role of man in modification of the environment and its influence on earthworm faunas. Some such factors may be more important than competition between endemics (possibly hemerophobic) and exotics that are strongly hemerophilic (favored by human culture).

But what evidence is there for a post-Quaternary northward earthworm migration? And from where? The answer now suggested: None worthy of much serious consideration. Obviously, migrating natives never reached Canada which lacks a single endemic species and even several American litter-feeders now domiciled elsewhere in the world—or New England, with Massachusetts and Connecticut each having but one record of a native species and each at a site to which the species obviously was introduced—or New York, with one to several isolated records of three litter-feeding natives but no records of any geophagous natives. Murchie (1954) found the sole geophagous native, *D. singularis*, only at four closely spaced localities of three contiguous Michigan counties. Of the American litter feeders, one was obtained from a single locality in each of five widely separated counties. Another was found at two localities of two widely separated counties. Another, *B. longicinctus*, was found at a single site of one county, just as in one county each of Illinois (Harman, 1960) and Ohio (Olson, 1928). In contrast, at least half a dozen European exotics are widely distributed throughout Michigan. A similar situation is shown by Olson's (1928) maps for Ohio. Of his three geophagous natives, two were recorded in Ohio only from a small central area. A third did have a greater north-south distribution

but the area involved was much smaller than that occupied by each of a half dozen European exotics. Four litter feeders were shown as from one of three localities each, but two others were indicated only from 12–13 counties, mostly in the central part of the state. Data for American species from Michigan and Ohio, like that for Massachusetts and Connecticut, suggest more recent and fewer introductions than of the exotic Europeans. In Indiana, four geophagous natives probably were present (Joyner, 1960) in 1960. Subsequently two more were added.

Fortunately, more recent results of three years' collecting in 46 central Illinois counties are available. Included of course was the Champaign-Urbana area of Smith's observations. One outstanding demonstration of the effects of man was provided by Harman's (1960) finding that all but one of Smith's stream bank species had disappeared since 1927 as a result of increased pollution. The sole survivor was the European manure worm, *Eisenia foetida*. Harman did think that *D. communis* (Idem: 66), though ranked sixth in number of times collected, "probably" was becoming less abundant but because of "present restriction to flood plains, occasional uncultivated areas and along roadside". Even so, the species was obtained in 20 collections from 16 counties (including Champaign) as against 21 collections from 15 counties for the supposedly replacing night crawler. Another geophagous native, *D. singularis*, mostly ignored in Smith's discussion, was even thought by Harman (1960: 69) "to be increasing its distribution" in central Illinois where it was secured in 18 collections from 11 counties. Not mentioned by Smith in 1928 was another geophagous native, *D. verrucosa*, he earlier characterized (Smith, 1915: 536) as "abundant" and which was obtained by Harman (1960) in 16 collections from 15 counties.

Even more interesting are the results of a Tennessee study (Reynolds *et al.*, 1974). Their figures show that 15 species of European worms are present in every one of the 95 counties of that state. None of the American species, whether litter feeders or geophagous, are as widely distributed as two or three of the European. As European earthworms were introduced directly or indirectly by man into every one of the 95 Tennessee counties, it is now possible to suggest that each of the native species, whether geophagous or litter feeders also could similarly have been brought into the state, and perhaps, less frequently and more recently. For more than a century, greenhouses, conservatories, etc., may have been importing and distributing exotic earthworms in the soil around the roots of live plants. ("During 1825–1860, wealthy estates in Tennessee and Kentucky had greenhouses. The Belmont mansion, near Nashville, had three buildings each 300 feet long." Gates, 1966: 251.)

Of the 23 European earthworm species now domiciled in North America, 18 of the most widely distributed frequently were intercepted (Gates, in MMS) at American ports of entry during the last 26 years. Each of the others is known only from one, two or several widely separated American sites. Accordingly, and regardless of how Julian's (1949)

habitat and life classifications are interpreted, each one of those colonizing European species seemingly can be regarded as hemerophilic as they owe so much of their distribution to man.

Detailed information that has been desired as to immediately post-Quaternary conditions in relation to earthworm life was not found in the literature. Answers were sought in vain to the following questions: Did not arctic gales, blowing for millenia across thousands of miles of thousand-foot thick ice, exterminate earthworms below the southernmost limit of glacial advance? If so, how far from the glacial boundary? Was there permafrost in the soil south of the glacial boundary? If so, at what depths and when did it finally disappear? How soon after disappearance of the ice would the deposited rock flour, sand, gravel and boulders have acquired enough organic matter to support geophagous earthworm populations? Did the Appalachian mountain tops, even shortly, have local glaciers? If so, how many centuries were required for geophagous earthworms to eat their way up to and then down the northern slopes of those mountains in order to digest their way through Tennessee and Kentucky into central Illinois? Originally, this author merely said (Gates, 1967: 174) "for as yet unknown distances below the southern ice face, the climate was too frigid for earthworms to survive." Later on, it was suggested (Gates, 1970: 9, No. 2) that the area of supposed extermination may have included all of the area north of the Appalachians (unfortunately, again without attracting interest, discussion or repercussions). Extermination is now suggested to have extended at least to the tops of the Appalachians if not also somewhat down on the southern side into what now appears to have been one of two earthworm refugia in North America.

The other refugium comprises a narrow strip along the Pacific coast about from San Francisco to the Canadian border. Between that strip and the 100th meridian of longitude, or thereabouts, endemic earthworms are lacking. An American species accidentally introduced from elsewhere may occasionally be found. Yet, wherever there is water, European and Asiatic worms flourish in a vast area that includes the region once marked on maps as "The Great American Desert". Efforts to obtain a geological explanation for the absence of native earthworms in such a large area have all been fruitless.

The "rival hypotheses" of Omodeo and Gates discussed by Ball (1976), again involved the amphi-atlantic distribution of the Lumbricidae. Two of its genera are endemic in a southern part of the United States. All other lumbricid genera (to as many as 14 according to which classification is followed) are endemic in Eurasia, for the family reaches into Korea and Japan. The origin and evolution of the Lumbricidae has had less consideration than that of some other megadrile families. An eastern origin of the family, because of the greater number of genera there, may have been assumed. However, possibility of an American origin but with greater Quaternary extinctions than in Eurasia, perhaps should be

considered. When a North Atlantic bridge for the lumbricids was first suggested cannot now be stated. Undoubtedly, it was assumed by that master architect of bridge builders, Wilhelm Michaelsen. Such a bridge was acceptable to Stephenson who argued effectively against Michaelson's other bridges. "A bridge between Europe and North America in comparatively recent times, over the most northerly part of the Atlantic, is, I think, well attested on geological grounds: it accounts for the presence of endemic lumbricids in the eastern United States" (Stephenson, 1930: 688). The word "endemic" of that previous sentence requires emphasis. Only because of the presence of endemics on both sides of that ocean was that bridge at first thought to be necessary.

Omodeo's contribution (1963) involved: Lumbricid origin in Eurasia. Migration of existing European species across the north Atlantic to Greenland and America. Survival there, morphologically unchanged, on nunataks, during the glacial period. Migration of American worms along the same bridge to Europe at the same time the European species were crossing to America.

The only genus that could be mentioned in that reverse direction was *Sparganophilus*. It is truly American, but is represented in Europe only at two sites in England and one in France, and there by the same species that in America (Jamieson, 1971: 814) extends from Central America to the Canadian shores of the Great Lakes. In marked contrast, European lumbricids reach all the way across North America both in the United States and Canada.

The author of the "hypothesis" attributed to Gates cannot now be mentioned. It may never have been developed in a formally logical way but was merely expressed as a probability (of high degree), as by Beddard in his monograph (1895: 155). With the inclusion of such geographical names as present knowledge permits, the "probability" of Beddard can be stated as follows: Presence of lumbricids invariably identical with those of Europe, in South Africa, the hills of south India, Australia, New Zealand, North and South America and oceanic islands such as St. Helena, Bermuda, St. Paul's Rock (Indian Ocean), Hawaii, etc., resulted from transportation; and by man. One attribute all such areas have in common is that Europeans have taken to each of those places live plants with their roots surrounded by earth. Before 1895 as well as subsequently, Beddard and others had commented on the earthworms often contained in such earth. Thousands of earthworms were intercepted by the U.S. Bureau of Plant Quarantine during the last 25 years in unsterilized materials associated with the roots of live plants. Often included in such interceptions were 18 of the 23 European lumbricids now domiciled in North America.

Both Ball and Omodeo derogated the evidence in support of Beddard's "probability" that has been accumulated by the present author (*cf.* Gates, 1966, 1967, 1972a: 62, 1972b, 1976, etc.). Ball (1976) for instance, while admitting "that some earthworms have been transported

by man," states, "we cannot from this logically infer that the entire distribution is a result of such transport." Fifty years study of earthworm literature never once revealed any such claim for even one species of earthworm. Indeed, the author often has emphasized the need to determine the original home of various widely distributed anthropochores. Also, observations of farmers (Ball, 1976: 410) seemingly are regarded as unimportant, although farmers who make their living through regular turning of the soil seem unusually well qualified to speak with authority on the absence of worms in the fields they tilled. However, persons other than farmers, including anglers as well as qualified natural history observers, have recorded again and again the absence of earthworms in various glaciated parts of Canada as well as the United States. Also noteworthy is the absence of a single endemic earthworm anywhere in Canada. That of course could have been predicted by anyone really familiar with the necessities of earthworm life as well as with conditions prevailing during the Quaternary glaciation and subsequently. Indeed that is what the present author almost did long ago (Gates, 1929).

Omodeo not only claimed that European earthworms were restricted to an eastern part of the United States (New England was specifically mentioned) but also that 200 years was insufficient to enable the present distribution. Actually more than 400 years is known to have been available for modern man to provide the present distributions. Columbus, on his second voyage to America, brought with him live plants. The English fishermen had been dumping earthen ballast in Newfoundland before there was any British settlement on the continent. Cortez returned live plants from Spain after his conquest of Mexico. Early English and Dutch settlers in New England and New York brought over pear trees, whose history has been followed, in large wooden tubs of earth. Eisen had found European lumbricids common as far west as California during the latter half of the 19th century. Finally, institutional and commercial as well as individual activity has been shown (Gates, 1966, 1967, etc.) to be adequate to have produced the present distribution of the European species on this continent.

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PROCEEDINGS
OF THE
BIOLOGICAL SOCIETY OF WASHINGTON

IDENTIFICATION OF THE AMERICAN
CYPRINODONTID FISH *HYDRARGIRA SWAMPINA*
LACÉPÈDE

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Hydrargira with its single included species, *swampina*, was described from Carolina by Lacépède (1803:378-380, pl. 10, fig. 3, p. 321). *Hydrargira* was emended to *Hydrargyra* by Cloquet (1821:102-103) and by many subsequent authors, including Valenciennes (in Cuvier and Valenciennes, 1846:203), Günther (1866:318), Jordan and Gilbert (1883:331), Garman (1895:96), and Jordan, Evermann, and Clark (1930:175). Jordan and Evermann (1896:632) retained the original spelling. Most workers since Günther (1866) have placed *Hydrargira* in the synonymy of *Fundulus* Lacépède (1803:37-39) whose type-species, as designated by Jordan and Gilbert (1883:331), is *Fundulus mudfish* Lacépède (1803:37-39), a synonym of *Cobitis heteroclitus* Linnaeus.

Hydrargira swampina Lacépède, type-species of *Hydrargira* by monotypy, has been considered a synonym of *Fundulus heteroclitus* (Linnaeus) by most workers, including Garman (1895:98), Jordan and Evermann (1896:641), Fowler (1916:416), and Jordan, Evermann, and Clark (1930:75, although they also equated the name with *F. majalis* on the same page). Garman (1895:98) incorrectly regarded *F. majalis* as type-

species of *Hydrargira*. Valenciennes created confusion by first stating (1836:228) that Lacépède's description was of the young of one species and the figure of a different species, and later (in Cuvier and Valenciennes, 1846:203) by describing specimens from New Jersey under the name *Hydrargyra swampina*. Valenciennes' *H. swampina* was correctly synonymized with *Fundulus diaphanus* by Jordan and Evermann (1896:645). If the customary placement of *H. swampina* as a synonym of *F. heteroclitus* is correct, *Hydrargira* is a synonym of *Fundulus*. Otherwise, since it antedates other generic and subgeneric names in or closely associated with *Fundulus*, the name is available.

Recently, Griffith (1974:320) "for reasons of priority [has employed] *F. swampinus* (Lacépède) rather than *F. lineolatus* as used by Rivas (1966)." The only documentation is Griffith's unpublished thesis (1972 Yale Ph.D. Dissertation) in which he stated (p. 250): "The description and figure given by Lacépède are unquestionably of the nominal *F. lineolatus* rather than *F. heteroclitus* or *F. diaphanus* as indicated by recent synonymies." *Fundulus lineolatus* (Agassiz, 1854) is in the *F. notti* species group (Wiley and Hall, 1975) which is assigned by some workers to the genus or subgenus *Zygonectes*. Wiley and Hall (1975:1) noted Griffith's substitution and suggested that "a ruling by the International Commission [for suppression of *swampina* based on Article 23] may be in order." We recognize neither desirability nor need to carry this issue to the Commission.

Lacépède's description and illustration (loc. cit.) of *H. swampina* are poor, but they provide no apparent basis for identification with *F. lineolatus*. His description differs from *F. lineolatus* in that *swampina* has 15 pectoral fin rays whereas *lineolatus* has 11–14 (Brown, 1958); *swampina* has 11 dorsal rays contrasting with 7–8 in *lineolatus* (data corrected from Brown, 1958); *swampina* has 12 anal rays rather than 8–10 in *lineolatus* (data corrected from Brown, 1958); and *swampina* reaches about 100 mm in length as against 80 mm in total length in *lineolatus*, which rarely exceeds 55 mm in standard length (based on large specimens from White Lake, North Carolina, in the Museum of Zoology, University of Michigan).

Lacépède's well-pigmented figure differs from *F. lineolatus* in that *swampina* has no subocular teardrop whereas *lineolatus* has one; *swampina* lacks the distinctive flank stripes of female *lineolatus*; *swampina* lacks rows of dots on the side, characteristic of male *lineolatus*; the vertical bars of *swampina* (14 shown in Lacépède's figure) are not distinctly thickened as they are in male *lineolatus*; the dorsal fin originates in front of rather than behind the origin of the anal fin as in *lineolatus*; and the body of *swampina* is more robust than the slender *lineolatus*.

Based on these differences, we reject identification of *Hydrargira swampina* Lacépède with *Fundulus lineolatus* (Agassiz). The identity of *H. swampina* Lacépède depends solely on the original description and figure because Lacépède based his description on manuscript notes given to him by Bosc and apparently deposited no types (pers. comm. from M. Martine Desoutter, Museum National d'Histoire Naturelle, Paris).

There are three other species of Carolina *Fundulus* which need be considered: *F. majalis*, *F. diaphanus*, and *F. heteroclitus*. *Fundulus majalis* can be eliminated because it typically has 12–14, usually 13, dorsal fin rays whereas *swampina* has 11, and Lacépède's figure shows neither the distinctive dorsal fin spot of male *majalis* nor the prominent horizontal body stripes of the female. *Fundulus diaphanus* (and its synonym *H. swampina* Valenciennes, 1846) can be eliminated because it has 12–15 dorsal rays rather than 11, and it usually has a higher number of pectoral rays (15) 16–17 in *diaphanus*; 15 in *swampina*. *Fundulus heteroclitus* generally agrees with Lacépède's meristic and color description. The configuration and height of the fins as shown in Lacépède's figure are not accurate for any Carolina species, but the shape and position of the anal fin better represent female *heteroclitus* than male *majalis* or male *diaphanus*. Finally, Lacépède's account of abundance and habitat support the identification of *swampina* with *heteroclitus*. We conclude that there is compelling evidence for the retention of *Hydrargira swampina* in the synonymy of *F. heteroclitus* and that *Hydrargira* is a synonym of *Fundulus*.

We thank Dr. Frank B. Cross who has graciously reviewed the manuscript.

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PROCEEDINGS
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A SECOND TROGLOBITIC SPECIES OF THE GENUS
LIRCEUS (ISOPODA, ASELLIDAE) FROM
SOUTHWESTERN VIRGINIA

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INTRODUCTION

The first known troglobitic species (i.e., obligatory cavernicole) of *Lirceus*, *L. usdagalun*, was described by Holsinger and Bowman (1973) from three caves in Lee County, Virginia. Prior to that time, 13 species of *Lirceus* had been described, all of which were primarily epigeal forms (Williams, 1972). The genus occurs in parts of the eastern and middle-western United States and the Great Lakes region of southern Ontario, Canada, where it is represented in a variety of aquatic habitats, including springs, seeps, streams, ponds, sloughs, woodland pools, lakes and drain outlets (Williams, 1972). Several species of *Lirceus*, other than *L. usdagalun*, also have been reported from cave stream habitats (see Holsinger and Bowman, 1973, for a summary), but all have pigment and small eyes and are considered troglaphiles and/or troglloxenes.

In August 1974, while doing field work in the caves of southwestern Virginia, Dr. David C. Culver and one of us (J. R. H.) discovered another population of eyeless, unpigmented *Lirceus* in a stream in McDavids Cave, Scott County, Virginia. A second trip to this cave in November 1975 resulted in the collection of additional specimens from the population. Surface habitats in Lee and Scott counties also were sampled for the presence of *Lirceus* to determine the taxonomic relationship between epigeal and hypogean species. On initial inspec-

tion the material from McDavids Cave appeared similar to *L. usdagalun*, but after closer study it proved to differ consistently in a number of morphological characters and is described below. The description of this new species brings the total number of described species in the genus to 15 and the number of troglobites to two.

All of the material examined in this study is deposited in the National Museum of Natural History, Smithsonian Institution (USNM), or in the collection of the junior author (JRH).

Lirceus culveri, new species

Figures 1-4

Material examined: Virginia. Scott Co.: McDavids Cave, holotype male (USNM 156148), 21 paratypes (USNM 156149) and 4 slide-mounted paratypes (JRH collection), J. A. Estes et al., 28 Nov. 1975; 10 paratypes (2 partly on slide mounts) (USNM 152631), J. R. Hol-singer and D. C. Culver, 3 Aug. 1974.

Diagnosis: An eyeless, unpigmented species closely allied morphologically with *Lirceus usdagalun* but distinguished from that species as follows: presence of only 1 heavy spine on small proximal process of gnathopod palm in both sexes; median process of palm of gnathopod small to prominent in mature male; spur of endopodite tip of male second pleopod slightly longer; distomedial margin of peduncle of male second pleopod without small spine and more weakly serrulate; uropod less setose, approximatly 20 percent length of pleotelson, exopod only about $\frac{1}{3}$ length of endopod. Largest male, 6.2 mm; largest female, 6.8 mm.

Description: Body about 64 percent longer than wide, with subparallel sides, not widening posteriorly. Head about 60 percent wider than long; lateral margin narrowly and deeply incised, anterior lobe about twice as wide as posterior lobe. Pereonites subequal, margins covered with fine setae. Pleotelson subtriangular, about 28 percent length of body, only slightly broader than long, narrowing posteriorly; median posterior process poorly delimited. Antenna 1: flagellum 5-segmented, last 2 to 4 segments bearing aesthetascs; first 2 peduncular segments with tufted setae (not shown in Fig. 2A). Antenna 2 relatively long but variable in length, 60 to 90 percent length of body; first peduncular segment with single stiff seta; peduncular segment 6 about 33 percent longer than 5, longer than combined length of first 4 peduncular segments; flagellum with up to 37 segments in largest specimen. Mandible without palp; incisor and lacinia mobilis 4-cuspidate (lacinia mobilis absent from right, present on left); spine row with 11 to 13 plumose spines on left, 15 on right; molar bearing clusters of subapical setae. Maxilla 1: outer plate with 12-13 apical spines, outermost 4 longer than inner ones; inner plate with 5 apical, plumose setae. Maxilliped: inner

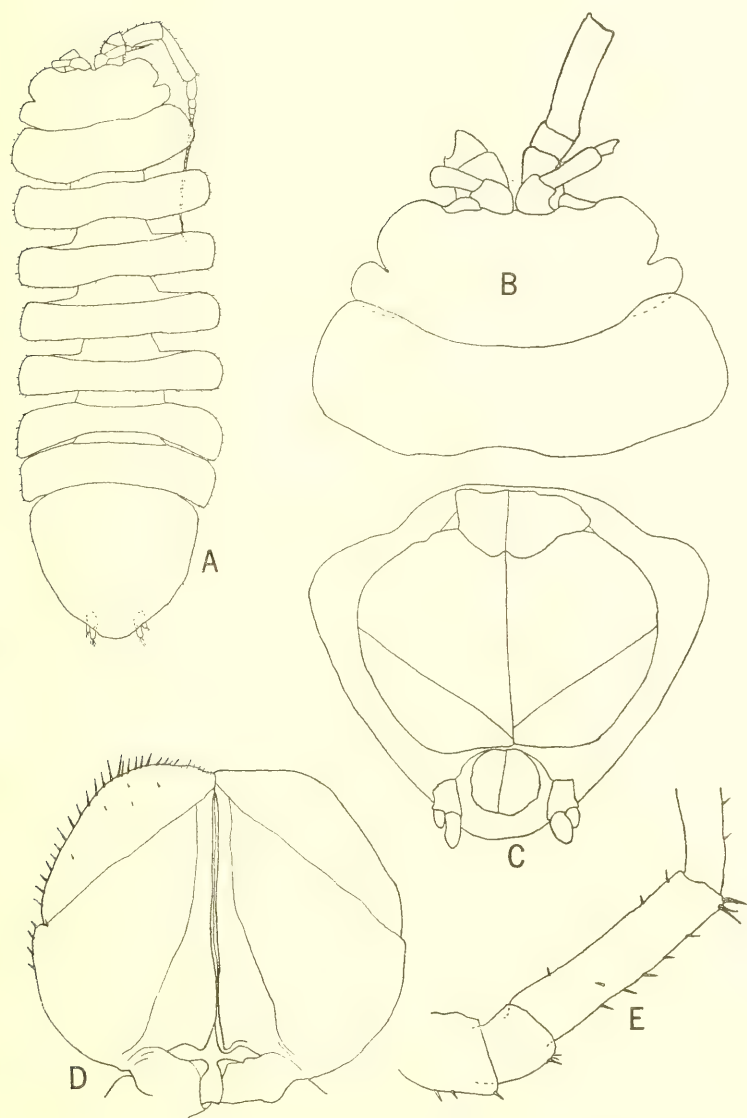


Fig. 1. *Lirceus culveri*, new species. Female paratype (5.9 mm): A, Dorsal view; B, Head and pereonite (setation omitted); C, Pleotelson and uropods, ventral (setation omitted). Male paratype (6.2 mm): D, Pleopod 3, anterior (setation shown only on one side); E, Left antenna 2, in part.

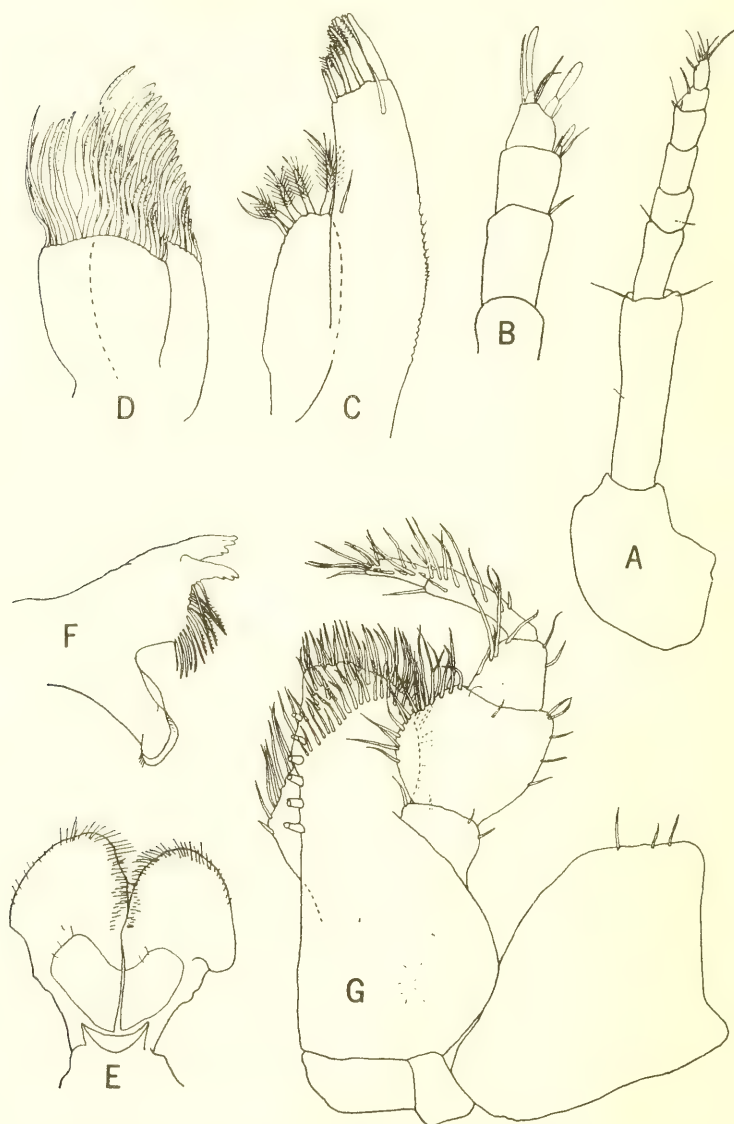


Fig. 2. *Lirceus culveri*, new species. Male paratype (6.0 mm): A, Right antenna 1, dorsal. Male paratype (6.2 mm): B, Terminal segments of antenna 1, dorsal (enlarged); C, Maxilla 1; D, Maxilla 2 (laminae of outer plate); E, Lower lip. Male paratype (5.2 mm): F, Left mandible; G, Left maxilliped, posterior.

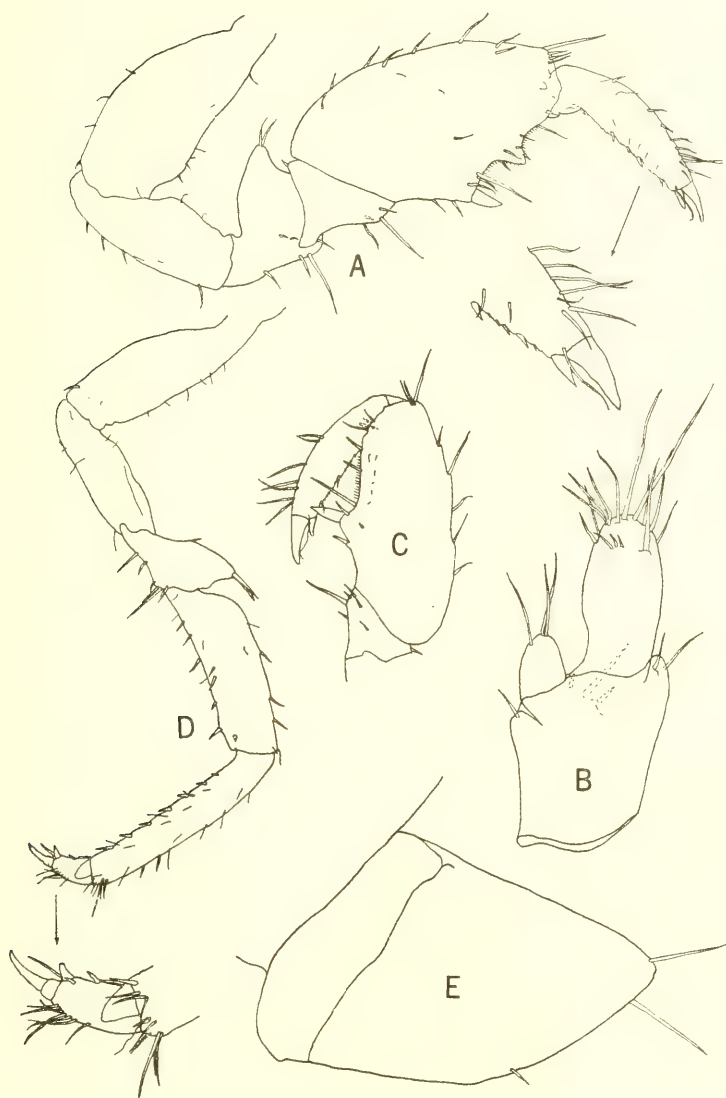


Fig. 3. *Lirceus culveri*, new species. Male paratype (5.2 mm): A, Left gnathopod, medial; B, Left uropod, dorsal. Female paratype (5.2 mm): C, Right gnathopod, medial. Male paratype (6.2 mm): D, pereopod 7. Female paratype (5.5 mm): E, Right pleopod 2, anterior.

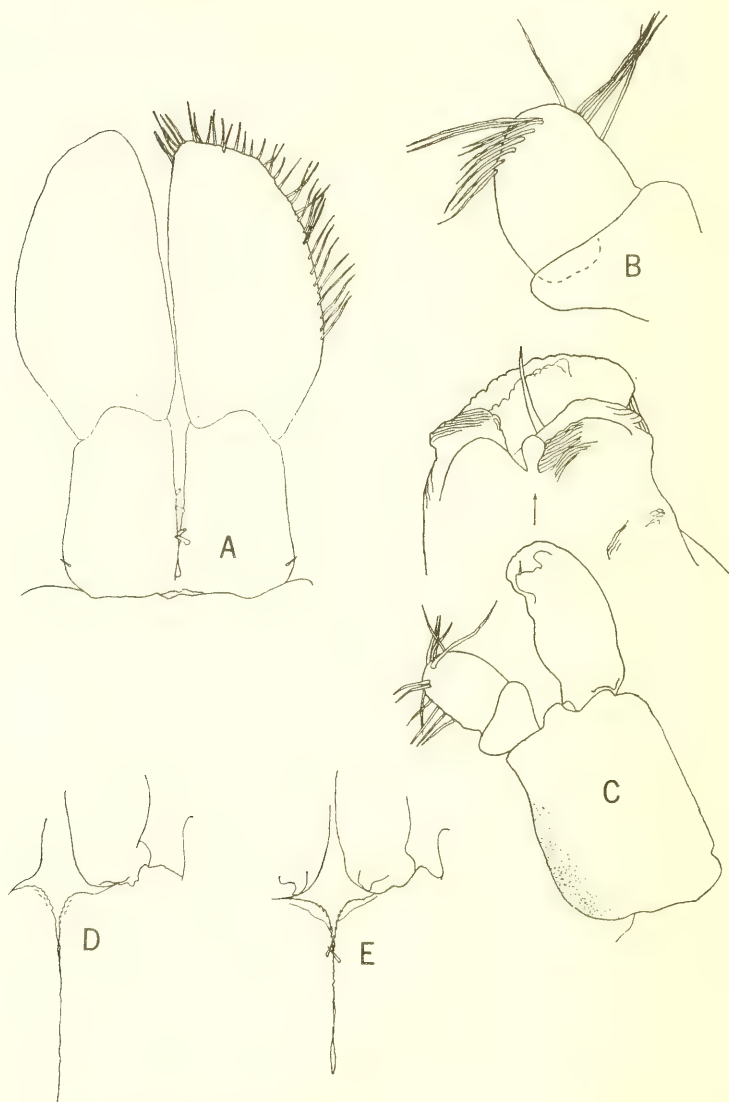


Fig. 4. *Lirceus culveri*, new species. Male paratype (6.2 mm): A, Pleopod 1, anterior (setation shown only on one side); B, Exopodite of pleopod 2, anterior (enlarged). Male paratype (6.0 mm): C, Pleopod 2, anterior (tip enlarged). Male paratype (5.2 mm): D, Inner margin of peduncle of pleopod 2. *Lirceus usdagalun* (4.8 mm male): E, Inner margin of peduncle of pleopod 2 (note comparison with that of *L. culveri*).

plate with row of apical, plumose setae; outer plate with 5–6 retinaculae on inner margin and numerous thick, plumose setae on apex; palpal segments 2–5 with numerous setae.

Gnathopod propod of male: palm rather oblique, with small proximal process bearing 1 heavy spine; median process of palm small to well developed, usually prominent in larger specimens. Gnathopod propod of female proportionately smaller than that of male; median process absent. Dactyls of pereopods 2–7 bearing 2 spines each. Male pleopod 1: peduncle 65–70 percent length of exopod, with 2–3 retinaculae; exopod nearly 50 percent longer than wide, inner margin nearly straight, unarmed; outer margin of exopod convex, armed with relatively long setae. Male pleopod 2: peduncle about $\frac{1}{3}$ longer than wide, distomedial margin weakly serrulate, without spines. Exopod of male pleopod 2 somewhat variable, slightly more than $\frac{1}{2}$ length of peduncle; distal segment subquadrate, bearing 5 long, very weakly barbed (not indicated in Fig. 4B, C), apical to subapical setae and 7–9 long, naked setae on lateral margin. Endopod 2 of male pleopod 2 suboblong, about twice as long as broad; apex with 3 distinct processes and 1 spur; caudal process broadly rounded, margin partly rugose; cephalic process smaller and less broadly rounded than caudal process, anterior surface rugose; mesial process with short stalk and flattened tip bent anteriorly; spur slender, finger-like, slightly curved, sometimes reaching just beyond caudal process. Female pleopod 2 short; lateral margin oblique distally, nearly straight proximally; apex with 2 long, terminal setae and 1 shorter subterminal seta. Pleopods 3–5 of both sexes generally similar to those of *L. usdagalun*. Uropod about 5.5 percent length of body, about 20 percent length of pleotelson; peduncle about as broad as long, a little more than twice as long as exopod; endopod about $\frac{2}{3}$ longer than exopod; rami bearing long, terminal setae.

Remarks: The small spine on the distomedial margin of the peduncle of male pleopod 2 of *L. usdagalun* was not indicated in Fig. 3C in the description of that species by Holsinger and Bowman (1973). A corrected illustration of this structure is provided by us in Fig. 4E.

Type-locality: McDavids Cave, located approximately 6 km northeast of Clinchport in the Rye Cove karst area of Scott Co., Virginia, is a large, stream-passage cave developed along the strike in the Rye Cove limestone of Middle Ordovician age (Holsinger, 1975).

Distribution and ecology: *L. culveri* is known only from the type-locality, where it has been collected twice from on and around gravels (some fused) in areas of the cave stream marked by riffles. Two other troglobitic crustaceans, the isopod *Asellus recurvatus* and the amphipod *Stygobromus mackini*, also inhabit the stream, but they generally occur on rocks and appear much less common than *L. culveri*. On the August 1974 visit, two small female crayfish, *Cambarus bartonii*, also were collected from the stream; this species is a troglophile or troglonexene.

The August 1974 collection contained five males and five females, two

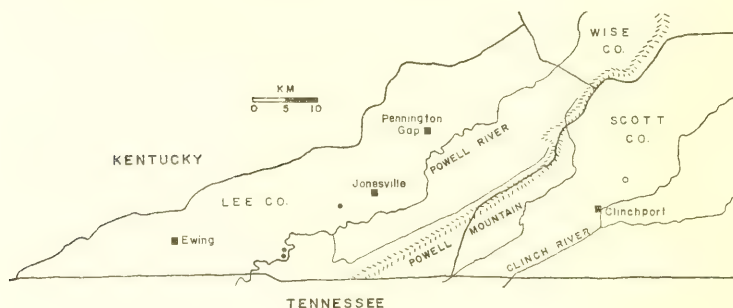


Fig. 5. Distribution of troglobitic species of *Lirceus* in southwestern Virginia: *L. culveri*, open circle (Scott County); *L. usdagalum*, closed circles (Lee County).

of which were ovigerous. The ovigerous females measured 5.6 and 7.8 mm and were carrying 18 and 28 eggs, respectively. The November 1975 collection contained nine males and 17 females, three of which were ovigerous or larviparous. Two of these females measured 4.8 and 4.9 mm and were carrying 11 and 13 newly-hatched young, respectively. The other female, 5.2 mm in length, had eight eggs in the brood pouch. Some of the newly-hatched young and eggs from the females in the latter collection were probably lost from the pouches before counts were made.

Etymology: It is a pleasure to name this new species in honor of our friend and colleague, Dr. David C. Culver, whose studies on the ecology of aquatic cave stream communities in the Appalachians have contributed substantially to our knowledge of biospeleology.

DISCUSSION

Morphologically and ecologically, *L. culveri* appears to be closely related to *L. usdagalum* and the two species probably share a relatively recent common ancestor. Although the morphological differences between these species are not great, they do, however, appear to be consistent and of enough significance to warrant separation of the two forms at the species-level. As presently known, *L. usdagalum* and *L. culveri* occur in separate karst areas in adjacent tributaries of the upper Tennessee River drainage basin—the former from the Powell River Valley and the latter from the Clinch River Valley. The ranges (see Fig. 5), which are allopatric, are situated approximately 45 km apart and are physically separated by the Powell Mountain and other potential barriers to the dispersal of aquatic cavernicoles.

In view of the absence of either of these species from surface seeps or springs and the fact that both appear to be confined ecologically to the substrates of cave streams, there is little, if any, possibility for gene

exchange between populations presumably isolated in separate karst areas. The ancestor to these species was probably an epigean form whose range covered parts of both the Powell and Clinch valleys, but which has since been eliminated from surface habitats.

L. usdagalun was originally described from three caves in Lee County by Holsinger and Bowman (1973) but has since been found in a fourth cave—Gallohan No. 2. However, the latter cave is hydrologically integrated with nearby Gallohan Cave No. 1 (type-locality of *L. usdagalun*) and these two caves share the same stream (Holsinger, 1975). The Gallohan caves are indicated by the same closed circle on the map in Fig. 5. As previously noted, *L. culveri* is known only from its type-locality, but the discovery of additional populations of this species from other nearby cave streams which contribute to the extensive subterranean drainage system in Rye Cove will not be surprising.

Several epigean species of *Lirceus* occur in the surface waters of the karst areas in Rye Cove and south-central Lee County. To gain further insight into the distribution of *Lirceus* in these areas and to check for similarities between the epigean and hypogean species, we searched several springs and small surface streams for populations of *Lirceus*. At least two, and possibly three, species were found, none of which can be assigned with certainty to any described species in the genus. All of these species differ significantly from *L. culveri* and *L. usdagalun*, especially in the structure of the gnathopods, shape of the head and usually the body, and in the proportionate length and setation of the uropods. In addition, the surface species are pigmented and eyed. One of these species, a small form (up to 6.0 mm in length) with yellow banding of the pereonites, was found in springs of both karst areas. A larger, unbande species (length up to 10.0 mm) was found in the surface stream of a blind valley leading to the entrance of Alley Cave in Rye Cove. Finally, a relatively small (up to 7.0 mm in length), lightly pigmented, eyed form was collected from the stream in Alley Cave. The stream in this cave is recharged from the surface stream in the blind valley and is, in turn, a subterranean tributary to the larger stream in McDavids Cave which contains *L. culveri*. The form in Alley Cave may be conspecific with the species in the surface feeder stream, but its size is smaller and the body is narrower and more lightly pigmented. This same lightly pigmented, narrow-bodied form was also found along with the small, yellow-banded species in a series of small springs which empty into Mill Creek on the eastern side of Rye Cove. It is perhaps of biological interest that these springs are the resurgence of the subterranean waters in McDavids Cave.

Further study is obviously necessary to ascertain the taxonomic relationship between the epigean species in Lee and Scott counties, and also to determine more precisely the relationship between the epigean and hypogean species. Considering the present taxonomic confusion in the genus *Lirceus* (see Styron, 1969; Williams, 1972; Holsinger and

Bowman, 1973), this may prove to be a difficult task until the systematics of the genus are adequately revised.

ACKNOWLEDGMENTS

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PROCEEDINGS
OF THE
BIOLOGICAL SOCIETY OF WASHINGTONCYCLOPOID COPEPODS ASSOCIATED WITH
TRIDACNIDAE (MOLLUSCA, BIVALVIA)
IN THE MOLUCCASBY ARTHUR G. HUMES
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In the Indo-West Pacific several cyclopoid copepods are associated with large tridacnid bivalves belonging to the genera *Tridacna* and *Hippopus*. Members of the copepod genera *Anthessius* and *Lichomolgus* live in the mantle cavity of these bivalves, while *Paclabius*, according to Kossmann (1877), inhabits the pericardium. Records of copepod associates of Tridacnidae, including the new information given below, are as follows:

<i>Anthessius solidus</i> Humes and Stock, 1965		
from <i>Tridacna squamosa</i>	Madagascar	Humes and Stock
Lamarck		(1965)
	Eniwetok Atoll	Humes (1972)
<i>Anthessius amicalis</i> Humes and Stock, 1965		
from <i>Tridacna squamosa</i>	Madagascar	Humes and Stock
		(1965)
	Eniwetok Atoll	Humes (1972)
	New Caledonia	Humes (1973)
from <i>Tridacna elongata</i>	Red Sea	Humes and Stock
Lamarck		(1965)
from <i>Tridacna maxima</i>	New Caledonia	Humes (1973)
(Röding)		
from <i>Hippopus hippopus</i>	Eniwetok Atoll	Humes (1972)
(Linnaeus)		
<i>Anthessius alatus</i> Humes and Stock, 1965		
from <i>Tridacna noae</i>	Red Sea	Humes and Stock
(Röding)		(1965)

from <i>Tridacna squamosa</i>	Madagascar	Humes and Stock (1965)
	Eniwetok Atoll	Humes (1972)
	New Caledonia	Humes (1973)
	Moluccas	present paper
from <i>Tridacna maxima</i>	New Caledonia	Humes (1973)
	Eniwetok Atoll	Humes (1972)
from <i>Tridacna gigas</i> (Linnaeus)	Eniwetok Atoll	Humes (1972)
<i>Anthessius discipedatus</i> new species		
from <i>Hippopus hippopus</i>	Moluccas	present paper
<i>Lichomolgus tridacnae</i> Humes, 1972		
from <i>Tridacna gigas</i>	Eniwetok Atoll	Humes (1972)
from <i>Tridacna squamosa</i>	Eniwetok Atoll	Humes (1972)
from <i>Hippopus hippopus</i>	Moluccas	present paper
<i>Lichomolgus hippopi</i> new species		
from <i>Hippopus hippopus</i>	Moluccas	present paper
<i>Paclabius tumidus</i> Kossmann, 1877		
from <i>Tridacna</i> sp.	Philippine Islands	Kossmann (1877)
from <i>Tridacna squamosa</i>	New Caledonia	Humes (1973)

Immediately after collection the Moluccan tridacnids were isolated individually in containers of sea water. Sufficient 95 percent ethyl alcohol was added to make a solution of about 5 percent. The adductor muscles were cut and the mantle cavity rinsed thoroughly. The sediment obtained was then strained through a fine net (mesh 74 holes per inch) and the copepods removed.

The observations and measurements of the two new species were made on specimens cleared in lactic acid. All figures were drawn with the aid of a camera lucida. The letter after the explanation of each figure refers to the scale at which it was drawn. The abbreviations used are: A_1 = first antenna, A_2 = second antenna, L = labrum, MXPD = maxilliped, and P_1 = leg 1.

The specimens were collected by the author during the ALPHA HELIX East Asian Bioluminescence Expedition which was supported by the National Science Foundation under grants OFS 74 01830 and OFS 74 02888 to the Scripps Institution of Oceanography and NSF grant BMS 74 23242 to the University of California, Santa Barbara.

I am indebted to Dr. Kenneth J. Boss, Museum of Compara-

tive Zoology, Harvard University, for the identification of the bivalve hosts.

MYICOLIDAE Yamaguti, 1936

Anthessius discipedatus, new species

Figures 1–24

Type material: 2 ♀ ♀, 6 ♂ ♂ from one bivalve, *Hippopus hippopus* (Linnaeus), length 26 cm, in 3 m, Gomumu Island, south of Obi, Moluccas, 1°50'00"S, 127°30'54"E, 30 May 1975. Holotype ♀, allotype, and 4 paratype ♂ ♂ deposited in the National Museum of Natural History (USNM), Washington; the remaining paratypes (dissected) in the collection of the author.

Female: Body (Fig. 1) similar in general shape to the three species of *Anthessius* from *Tridacna* described by Humes and Stock, 1965. Length (not including the setae on the caudal rami) 1.46 mm (1.39–1.54 mm) and the greatest width 0.61 mm (0.58–0.64 mm), based on 2 specimens in lactic acid. Prosoma moderately flattened, with the cephalosome slightly indented near the level of the maxillipeds. Epimeral areas pronounced and rounded. Segment bearing leg 1 separated incompletely from the head by a transverse dorsal furrow. Ratio of the length to the width of the prosome 1.52:1. Ratio of the length of the prosome to that of the urosome 1.70:1.

Segment of leg 5 (Fig. 2) $120 \times 348 \mu\text{m}$. Genital segment $198 \times 292 \mu\text{m}$, tapered in its posterior half. Genital areas located laterally on the midregion of the segment. Each area (Fig. 3) with 2 small naked setae approximately $10 \mu\text{m}$ long. Three postgenital segments from anterior to posterior 86×156 , 73×143 , and 83 (114 in middle length) $\times 140 \mu\text{m}$. Genital and first 2 postgenital segments ventrally with a row of delicate spinules along the posterior border. Anal segment with a pair of ventral crescentic groups of 6–8 spines anteriorly (Fig. 4) and with a posteroventral row of minute spinules on either side near the caudal ramus.

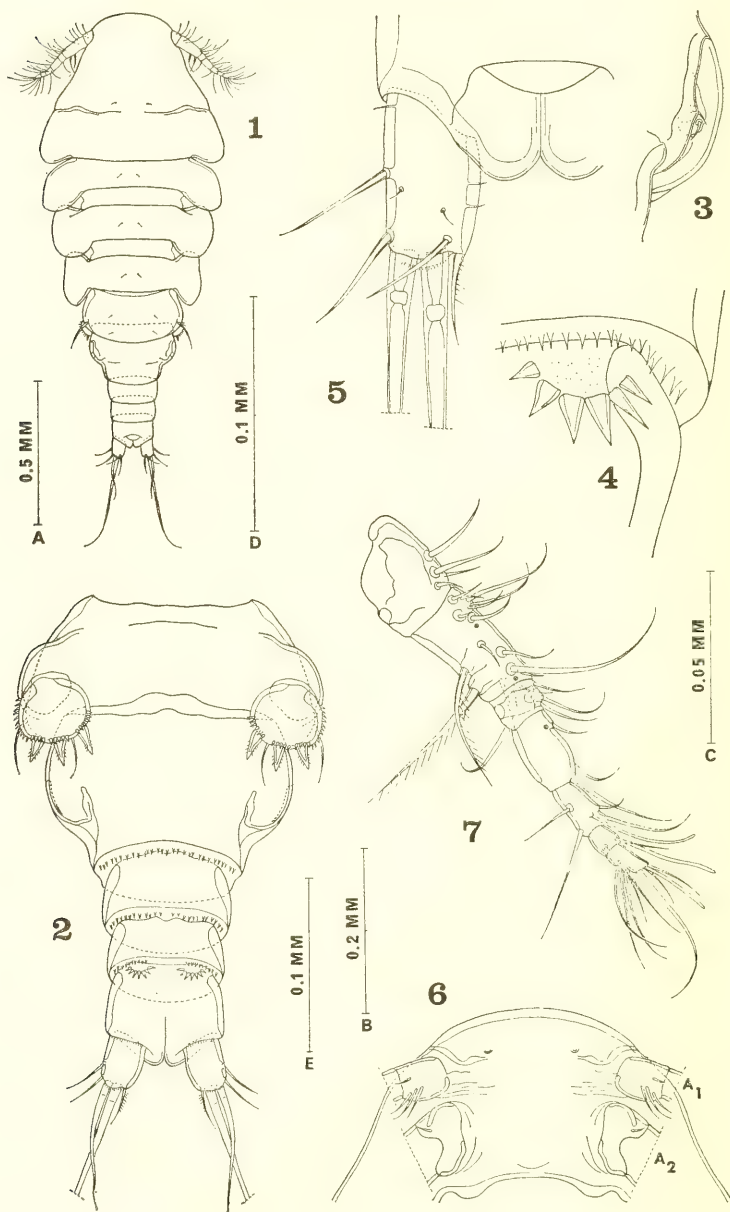
Caudal ramus (Fig. 5) $68 \times 39 \mu\text{m}$, ratio of length to width 1.74:1. Outer lateral seta $52 \mu\text{m}$, dorsal seta $42 \mu\text{m}$, and outermost terminal seta $47 \mu\text{m}$, all naked. Innermost terminal seta $39 \mu\text{m}$ with hairs along the inner margin. Two median naked terminal setae $170 \mu\text{m}$ (outer) and $385 \mu\text{m}$ (inner), both inserted between small dorsal (smooth) and ventral (with a marginal row of very small spinules) flanges.

Body surface with a few hairs (sensilla) as shown in Figure 1.

Egg sac unknown.

Rostrum (Fig. 6) weakly developed.

First antenna (Fig. 7) $242 \mu\text{m}$ long. Lengths of the 7 segments (measured along their posterior margins): 21 ($55 \mu\text{m}$ along the anterior margin), 58, 21, 42, 34, 14, and $18 \mu\text{m}$ respectively. Formula: 4, 15 ($7 + 8$), 6, 3, 4 + 1 aesthete, 2 + 1 aesthete, and 7 + 1 aesthete. All



setae naked except 2 large setae on segment 2 which are feathered along one side.

Second antenna (Fig. 8) 213 μm long including the claws. Each of the first two segments with a small naked seta. Third segment with 3 setae, two of them lightly barbed, and a stout spine. Area representing the fourth segment fused with the third segment and bearing 4 large jointed claws, 2 large barbed setae, and a small naked seta.

Labrum (Fig. 9) with 2 broad posteroventral lobes. Each lobe ornamented on its distal outer margin with a row of small teeth followed by a large spiniform process, and on its inner medial margin by a conical process with a truncated hyaline tip.

Mandible (Fig. 10) slender, resembling in general form that of other *Anthessius* species. Two spines near the base of the apical lash bifurcated (Fig. 11). Between the apical lash and the opposing long setiform element 2 unequal hyaline lobes. Paragnath a small lobe (Fig. 9). First maxilla (Fig. 12), second maxilla, and maxilliped resembling in general form those of other *Anthessius* species.

Ventral area between the maxillipeds and the first pair of legs (Fig. 15) not protuberant.

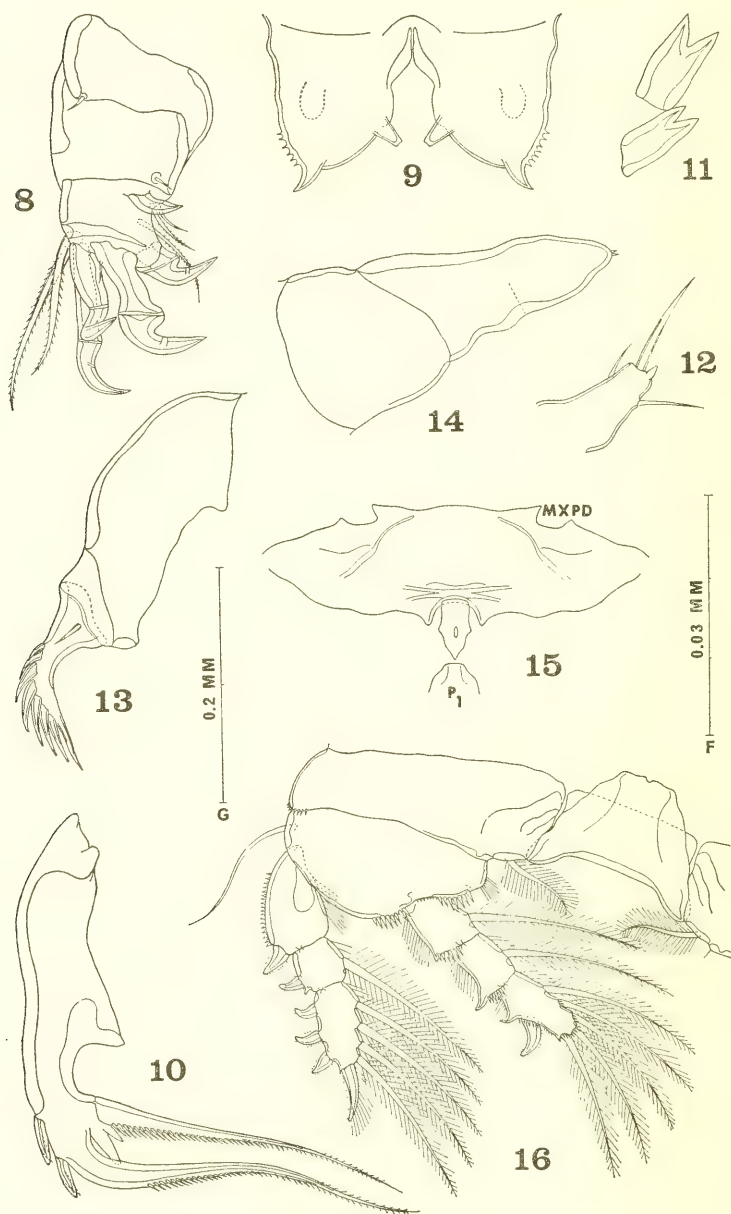
Legs 1-4 segmented as in other *Anthessius* species. Third segment of the exopod of leg 4 with the formula III, I, 5. Spine and setal formula as follows (Roman numerals representing spines, Arabic numerals indicating setae):

P ₁	coxa	0-1	basis	1-0	exp	I-0;	I-1;	III, I, 4
					enp	0-1;	0-1;	I, 5
P ₂	coxa	0-1	basis	1-0	exp	I-0;	I-1;	III, I, 5
					enp	0-1;	0-2;	III, 3
P ₃	coxa	0-1	basis	1-0	exp	I-0;	I-1;	III, I, 5
					enp	0-1;	0-2;	IV, 2
P ₄	coxa	0-1	basis	1-0	exp	I-0;	I-1;	III, I, 5
					enp	0-1;	0-2;	IV, 1

Leg 5 (Fig. 20) carried ventrally and largely hidden in dorsal view. Free segment discoid, $70 \times 83 \mu\text{m}$, slightly wider than long. Usual 4 elements consisting of 3 stout barbed spines (21, 26, and $31 \mu\text{m}$ from outer to inner) and a slender naked seta $33 \mu\text{m}$. Margin of the segment ornamented with stout spinules. Dorsal seta $38 \mu\text{m}$ and naked.

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FIGS. 1-7. *Anthessius discipedatus* new species, female: 1, Dorsal (A); 2, Urosome, ventral (B); 3, Genital area, dorsal (C); 4, Group of spines on anal segment, ventral (C); 5, Caudal ramus, dorsal (D); 6, Rostral area, ventral (B); 7, First antenna, with 3 dots indicating positions of aesthetes added in the male, ventral (E).



Leg 6 represented by the 2 small setae on the genital area (Fig. 3).

Living specimens in transmitted light slightly opaque, the eye red.

Male: Body (Fig. 21) resembling that of the female. Length (excluding the setae on the caudal rami) 1.28 mm (1.25–1.31 mm) and the greatest width 0.50 mm (0.48–0.51 mm), based on 6 specimens in lactic acid. Ratio of the length to the width of the prosome 1.63:1. Ratio of the length of the prosome to that of the urosome 1.50:1.

Segment of leg 5 (Fig. 22) $78 \times 280 \mu\text{m}$. Genital segment $177 \times 263 \mu\text{m}$ (length including leg 6). Four postgenital segments from anterior to posterior 62×178 , 65×159 , 60×143 , and $68 \times 135 \mu\text{m}$. Crescentic groups of spines on ventral surface of anal segment with 7–10 spines.

Caudal ramus similar to that of the female, but smaller, $60 \times 42 \mu\text{m}$, ratio 1.43:1.

Body surface ornamented as in the female.

Rostrum like that of the female. First antenna resembling that of the female but 3 aesthetes added, 2 on the second segment and one on the fourth segment, their positions indicated by small dots in Figure 7, so that the formula is: 4, 15 + 2 aesthetes, 6, 3 + 1 aesthete, 4 + 1 aesthete, 2 + 1 aesthete, and 7 + 1 aesthete. Second antenna, labrum, mandible, paragnath, first maxilla, and second maxilla as in the female. Maxilliped (Fig. 23) 4-segmented, assuming that the proximal part of the claw represents a modified fourth segment. First segment with a distal postero-inner row of spinules. Second segment with 2 small naked setae and several groups of spines. Small third segment with a finely barbed seta and a spiniform process. Claw (Fig. 24) $139 \mu\text{m}$ along its axis, with a small proximal seta and a distal anterior surficial row of small blunt spinules.

Ventral area between the maxillipeds and the first pair of legs as in the female.

Legs 1–4 like those of the female.

Leg 5 (Fig. 22) resembling that of the female. Free segment $62 \times 65 \mu\text{m}$.

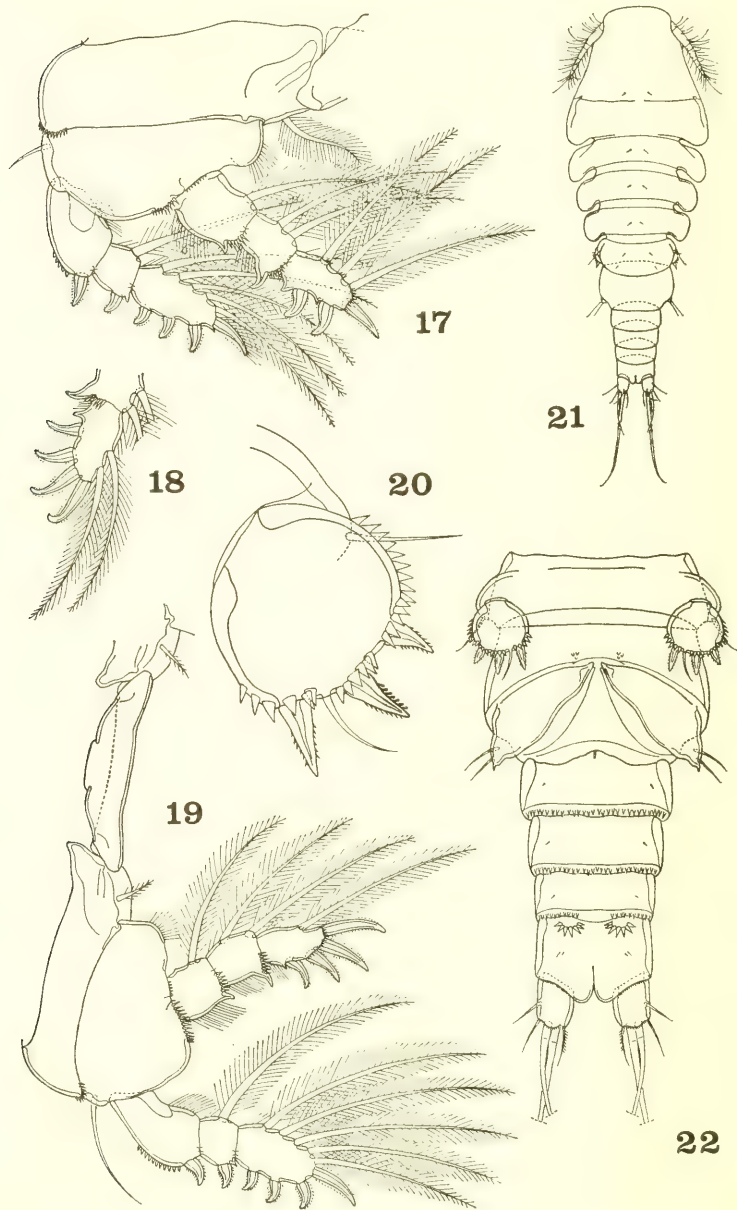
Leg 6 (Fig. 22) a posteroventral flap on the genital segment bearing 2 naked setae $40 \mu\text{m}$ and $35 \mu\text{m}$.

Spermatophore not seen.

Color as in the female.

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FIGS. 8–16. *Anthessius discipedatus* new species, female: 8, Second antenna, antero-inner (E); 9, Labrum, with position of paragnaths indicated by broken lines, ventral (D); 10, Mandible, anterior (C); 11, Two spines on mandible near base of apical lash, ventral (F); 12, First maxilla, posterior (C); 13, Second maxilla, posterior (C); 14, Maxilliped, inner (C); 15, Area between maxillipeds and first pair of legs, ventral (G); 16, Leg 1 and intercoxal plate, anterior (E).



Etymology: The specific name *discipedatus*, from Latin *discus* = a disk or plate and *pedatus* = provided with feet, alludes to the discoid form of leg 5.

Comparison with other species: In the genus *Anthessius* 32 species are recognized (not including the new species described here). Twenty-three were listed by Stock, Humes, and Gooding (1963). Since then 9 more have been described: *A. saecularis* Stock, 1964, *A. solidus* Humes and Stock, 1965, *A. amicalis* Humes and Stock, 1965, *A. alatus* Humes and Stock, 1965, *A. dolabellae* Humes and Ho, 1965, *A. stylocheili* Humes and Ho, 1965, *A. distensus* Humes and Ho, 1965, *A. mytilicolus* Reddiah, 1966, and *A. punctadae* Humes, 1973.

Three features of *A. discipedatus* are distinctive and serve as useful recognition characters, since in no other species in the genus, as far as known, are all 3 of these features present. In the first place, the discoid free segment is not found elsewhere, although the fifth legs of *A. amicalis* approach the discoidal form, especially in the male. Secondly, the ornamented labrum is unique, although it should be stated that the form of the labrum is unknown in half the species described. Thirdly, one of the 4 subterminal elements on the third segment of the second antenna is a strong stout spine. In the 3 species from *Tridacna* (*A. solidus*, *A. amicalis*, and *A. alatus*) one of these elements is a very weak spine. In all other species, as far as known, all 4 elements are setae.

The new species shows 2 features characteristic of other *Anthessius* associated with Tridacnidae (*A. solidus*, *A. amicalis*, and *A. alatus*): 1) the indentation of the cephalosome near the level of the maxillipeds and 2) the development of the epimeral areas on the prosome.

Anthessius alatus Humes and Stock, 1965

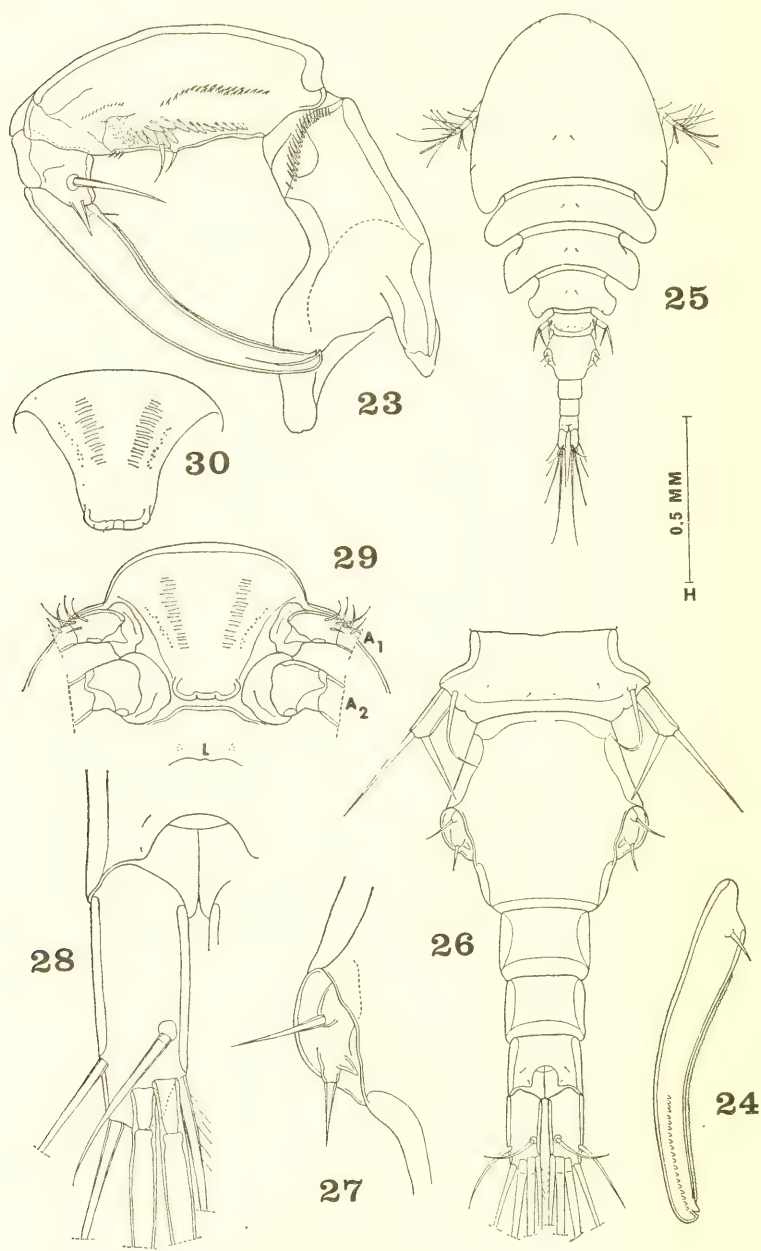
This copepod has been reported from *Tridacna noae* (Röding) in the Red Sea (Humes and Stock, 1965), from *Tridacna squamosa* Lamarck in Madagascar (Humes and Stock, 1965), at Eniwetok Atoll (Humes, 1972), and in New Caledonia (Humes, 1973), from *Tridacna maxima* (Röding) at Eniwetok Atoll (Humes, 1972) and in New Caledonia (Humes, 1973), and from *Tridacna gigas* (Linnaeus) at Eniwetok Atoll (Humes, 1972).

Specimens collected: From *Tridacna squamosa*: 4♀♀, 5♂♂, 4 copepodids from one host, length 14 cm, in 10 m, southern shore of

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FIGS. 17-20. *Anthessius discipedatus* new species, female: 17, Leg 2, anterior (E); 18, Third segment of endopod of leg 3, anterior (E); 19, Leg 4 and intercoxal plate, anterior (E); 20, Leg 5, ventral (D).

FIGS. 21-22. *Anthessius discipedatus* new species, male: 21, Dorsal (A); 22, Urosome, ventral (B).



Goenoeng Api, Banda Islands, Moluccas, 4°32'05"S, 129°52'30"E, 26 April 1975; 2♀♀, 3♂♂, 4 copepodids from one host, length 12 cm, in 10 m, southwestern shore of Goenoeng Api, Banda Islands, 4°31'24"S, 129°51'55"E, 28 April 1975; 6♀♀, 4♂♂, 2 copepodids from one host, length 11 cm, in 3 m, Gomumu Island, south of Obi, Moluccas, 1°50'00"S, 127°30'54"E, 30 May 1975.

LICHOMOLGIDAE Kossmann, 1877

Lichomolgus hippopi, new species

Figures 25–51

Type material: 11♀♀, 11♂♂ from one bivalve, *Hippopus hippopus* (Linnaeus), length 26 cm, in 3 m, Gomumu Island, south of Obi, Moluccas, 1°50'00"S, 127°30'54"E, 30 May 1975. Holotype ♀, allotype, 17 paratypes (8♀♀, 9♂♂) deposited in the National Museum of Natural History (USNM), Washington; the remaining paratypes (dissected) in the collection of the author.

Female: Body (Fig. 25) with the prosome moderately expanded. Length (excluding the setae on the caudal rami) 1.29 mm (1.22–1.35 mm) and the greatest width 0.60 mm (0.56–0.64 mm), based on 10 specimens in lactic acid. Segment of leg 1 incompletely separated from the head in dorsal view. Ratio of the length to the width of the prosome 1.52:1. Ratio of the length of the prosome to that of the urosome 2.24:1.

Segment of leg 5 (Fig. 26) $70 \times 169 \mu\text{m}$. Between this segment and the genital segment no ventral sclerite. Genital segment $146 \times 166 \mu\text{m}$, a little wider than long, in dorsal view broadest in the midregion. Genital areas located at the widest part of the segment. Each area (Fig. 27) bearing 2 naked setae 33 and $22 \mu\text{m}$ and a small dentiform process. Three postgenital segments from anterior to posterior 52×75 , 44×66 , $42 \times 60 \mu\text{m}$. Anal segment with a smooth posteroventral margin.

Caudal ramus (Fig. 28) $66 \times 27 \mu\text{m}$, about 2.44 times longer than wide. Outer lateral seta $73 \mu\text{m}$, the dorsal seta $47 \mu\text{m}$, the outermost terminal seta $86 \mu\text{m}$, the innermost terminal seta $112 \mu\text{m}$, and the 2 long median terminal setae $208 \mu\text{m}$ (outer) and $355 \mu\text{m}$ (inner), both inserted dorsally to a small ventral flange with a smooth margin. All setae naked except the innermost terminal seta which has a few proximal inner hairs.

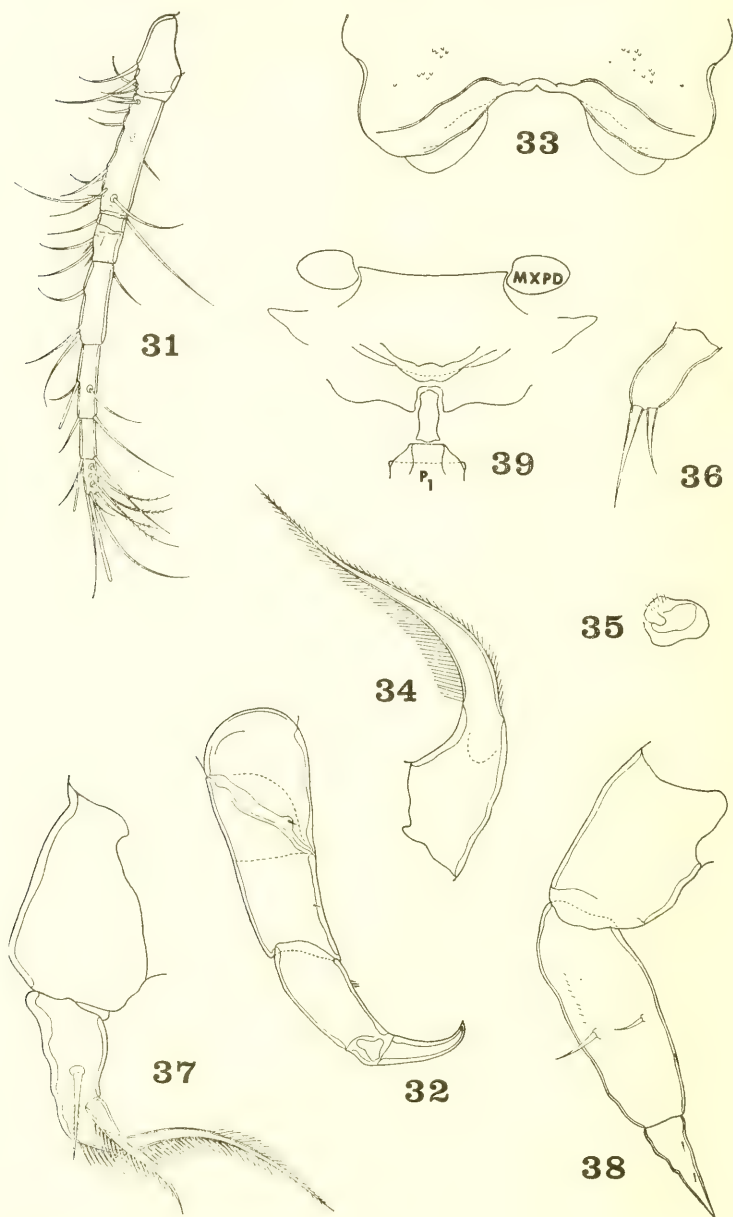
Body surface with a very few hairs (sensilla) as in Figure 25.

Egg sacs fragmentary in all ovigerous specimens. Each egg approximately $104 \mu\text{m}$ in diameter and slightly irregular in shape.

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FIGS. 23–24. *Anthessius discipedatus* new species, male: 23, maxilliped, postero-inner (D); 24, Claw of maxilliped, antero-outer (D).

FIGS. 25–30. *Lichomolgus hippopi* new species, female: 25, Dorsal (H); 26, Urosome, dorsal (G); 27, Genital area, dorsal (C); 28, Caudal ramus, dorsal (C); 29, Rostrum, ventral (B); 30, Rostrum, ventral (B).



Rostrum (Fig. 29) well-developed, reaching to a level between the bases of the second antennae. Posteroventral tip of the rostrum truncated rather than pointed and variously thickened (Fig. 30).

First antenna (Fig. 31) 396 μm long. Lengths of the 7 segments (measured along their posterior margins): 26 (65 μm along the anterior edge), 99, 39, 64, 60, 34, and 29 μm respectively. Formula for the armature: 4, 13, 6, 3, 4 + 1 aesthete, 2 + 1 aesthete, and 7 + 1 aesthete. All setae naked except 4 on the seventh segment which are weakly haired.

Second antenna (Fig. 32) 234 μm long. First and second segments with a very small inner seta. Third segment (combined third and fourth segments) with 3 minute inner setae. No subterminal armature. Claw 54 μm along its axis.

Labrum (Fig. 33) with 2 widely divergent, broad, posteroventral lobes. Mandible (Fig. 34), paragnath (Fig. 35), first maxilla (Fig. 36), second maxilla (Fig. 37), and maxilliped (Fig. 38) similar in most respects to those of *Lichomolgus tridacnae* Humes, 1972. Third segment of the maxilliped with 2 minute setae.

Ventral area between the maxillipeds and the first pair of legs (Fig. 39) not protuberant.

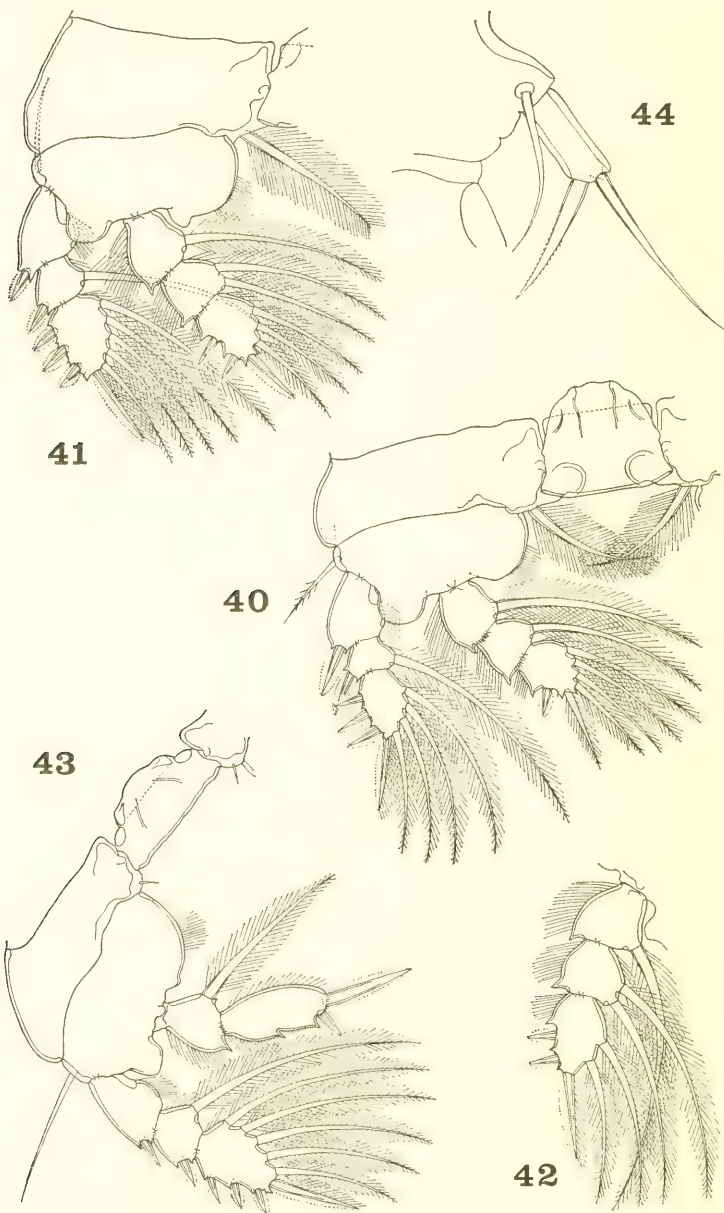
Legs 1-4 (Figs. 40, 41, 42, 43) with 3-segmented rami except for the endopod of leg 4 which is 2-segmented. Formula for the armature as follows (Roman numerals representing spine, Arabic numerals indicating setae):

P ₁	0-1	1-0	exp	I-0;	I-1;	III, I, 4
			enp	0-1;	0-1;	I, 5
P ₂	0-1	1-0	exp	I-0;	I-1;	III, I, 5
			enp	0-1;	0-2;	I, II, 3
P ₃	0-1	1-0	exp	I-0;	I-1;	III, I, 5
			enp	0-1;	0-2;	I, II, 2
P ₄	0-1	1-0	exp	I-0;	I-1;	III, I, 5
			enp	0-1;	II	

Inner coxal seta on legs 1-3 long and plumose, but on leg 4 this seta short (10 μm) and naked. Inner margin of the basis in all 4 legs with a row of hairs. Exopod of leg 4 114 μm long. First segment of the endopod 36 \times 31 μm with hairs along the outer margin. Second segment

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FIGS. 31-39. *Lichomolgus hippopi* new species, female: 31, First antenna, dorsal (G); 32, Second antenna, anterior (E); 33, Labrum, ventral (D); 34, Mandible, anterior (C); 35, Paragnath, ventral (C); 36, First maxilla, anterior (C); 37, Second maxilla, posterior (C); 38, Maxilliped, inner (C); 39, Area between maxillipeds and first pair of legs, ventral (G).



$57 \times 29 \mu\text{m}$ (width taken at the spine), the 2 terminal delicately fringed spines $15.5 \mu\text{m}$ (outer) and $55 \mu\text{m}$ (inner). Outer margin of this segment with a small thornlike process and provided proximally with long hairs and distally with short barbules; inner margin of the segment with delicate hairs.

Leg 5 (Fig. 44) with a small unornamented free segment $42 \times 16 \mu\text{m}$, bearing 2 unequal terminal setae, one naked and $80 \mu\text{m}$, the other a stouter very finely barbed seta $55 \mu\text{m}$. Adjacent seta on the body $65 \mu\text{m}$ and naked.

Leg 6 represented by the 2 setae on the genital area (Fig. 27).

Living specimens in transmitted light opaque, the eye red, and eggs dark gray.

Male: Body (Fig. 45) slender. Length (without the setae on the caudal rami) 0.89 mm ($0.88\text{--}0.90 \text{ mm}$) and the greatest width 0.26 mm ($0.24\text{--}0.29 \text{ mm}$), based on 10 specimens in lactic acid. Ratio of the length to the width of the prosome $2.02:1$. Ratio of the length of the prosome to that of the urosome $1.56:1$.

Segment of leg 5 (Fig. 46) $31 \times 75 \mu\text{m}$. Genital segment elongated, $125 \times 102 \mu\text{m}$. Four postgenital segments from anterior to posterior 43×56 , 42×49 , 36×44 , and $32 \times 47 \mu\text{m}$.

Caudal ramus (Fig. 46) resembling that of the female, but smaller, $52 \times 21 \mu\text{m}$, ratio $2.48:1$.

Body surface very lightly ornamented as in the female.

Rostrum, first antenna, second antenna, labrum, mandible, paragnath, first maxilla, and second maxilla like those of the female. Maxilliped (Fig. 47) slender and 4-segmented (assuming that the proximal half of the claw represents a fourth segment). First and third segments unarmed. Second segment with 2 setae, one of them broad with a lateral setiform projection (Fig. 48), and with 2 rows of small spinules. Claw $121 \mu\text{m}$ along its axis including the terminal lamella, partly divided about midway, and bearing proximally 2 very unequal smooth setae.

Ventral area between the maxillipeds and the first pair of legs resembling that of the female.

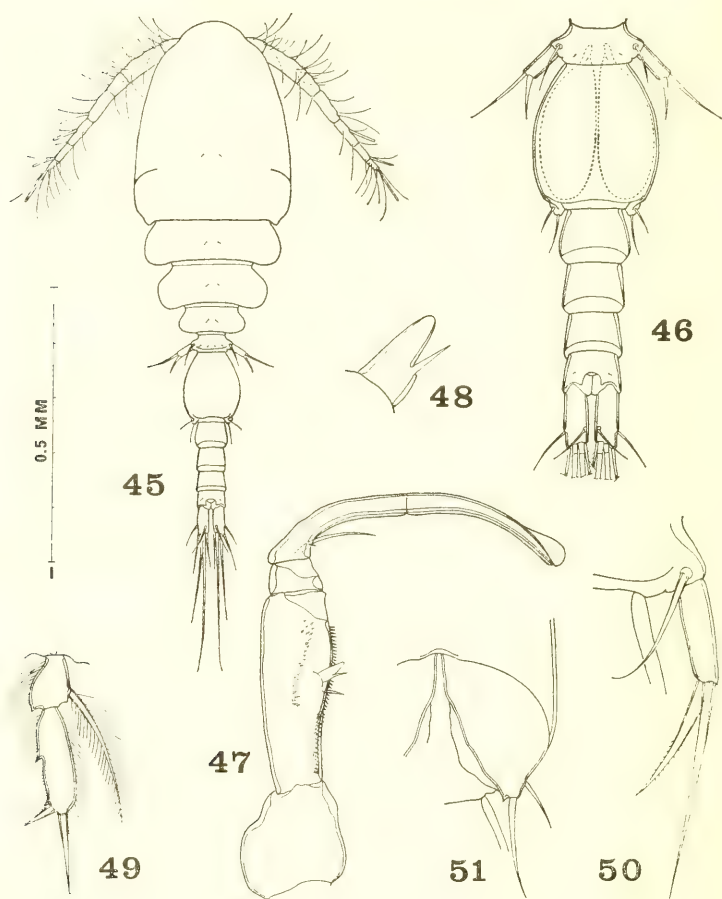
Legs 1–4 like those of the female except for the more slender second segment of the endopod of leg 4 (Fig. 49) which is $59 \times 19 \mu\text{m}$.

Leg 5 (Fig. 50) similar to that of the female but smaller and slenderer, $32 \times 10 \mu\text{m}$, with the terminal setae 60 and $39 \mu\text{m}$.

Leg 6 (Fig. 51) a posteroventral flap on the genital segment bearing 2 naked setae $35 \mu\text{m}$ and $22 \mu\text{m}$.

←

FIGS. 40–44. *Lichomolgus hippopi* new species, female: 40, Leg 1 and intercoxal plate, anterior (E); 41, Leg 2, anterior (E); 42, Endopod of leg 3, anterior (E); 43, Leg 4 and intercoxal plate, anterior (E); 44, Leg 5, dorsal (D).



FIGS. 45-51. *Lichomolgus hippopi* new species, male: 45, Dorsal (I); 46, Urosome, dorsal (G); 47, Maxilliped, antero-inner (D); 48, Modified spine on second segment of maxilliped, antero-inner (F); 49, Endopod of leg 4, anterior (E); 50, Leg 5, dorsal (C); 51, Leg 6, ventral (D).

Living specimens in transmitted light colored as in the female.

Etymology: The specific name *hippopi* is the genitive form of the generic name of the host.

Comparison with related species: Among the 18 species of *Lichomolgus* listed by Humes and Stock, 1973, there are 6 which, like the new species, have only one claw on the second antenna. In 5 of these species the rostrum is broadly rounded posteroventrally and does not extend be-

tween the bases of the second antenna (*Lichomolgus arcanus* Humes and Cressey, 1958, *L. asaphidis* Humes, 1959, *L. inflatus* Tanaka, 1961, *L. spondyli* Yamaguti, 1936, and *L. tridacnae* Humes, 1972). In the sixth of these species, *L. chamarum* Humes, 1968, the rostrum is elongated and extends between the bases of the second antennae. The tip of the rostrum in this species, however, is pointed rather than truncated as in *Lichomolgus hippopi*.

The new species differs from all known *Lichomolgus* in having the formula III, I, 5 instead of II, I, 5 on the third segment of the exopod of leg 4. Since other features of *L. hippopi* are typically those of *Lichomolgus*, this variation in the number of outer exopod spines on leg 4 is best interpreted as intrageneric. Other lichomolgid genera show both formulas (II, I, 5 or III, I, 5),—for example, *Anisomolgus* Humes and Stock, 1972, *Macrochiron* Brady, 1872, *Monomolgus* Humes and Frost, 1964, and *Panjakus* Humes and Stock, 1972.

Lichomolgus tridacnae Humes, 1972

This species has been previously reported from *Tridacna gigas* (Linnaeus) and *Tridacna squamosa* Lamarck at Eniwetok Atoll, Marshall Islands (Humes, 1972).

Specimens collected: 1 ♀, 1 ♂ from the same specimen of *Hippopus hippopus* from which *Anthessius discipedatus* and *Lichomolgus hippopi* were recovered; in 3 m, Gomumu Island, south of Obi, Moluccas, 1°50'00"S, 127°30'54"E, 30 May 1975.

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PROCEEDINGS
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A REPLACEMENT NAME FOR *TANGIA* CHAN (PISCES:
PERCIFORMES: LUTJANIDAE) WITH REDESCRIP-
TIONS OF THE GENUS AND TYPE-SPECIES

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Chan (1970) described a new lutjanid genus and species, *Tangia carnolabrum*, from specimens collected in the South China Sea. Since the publication of Chan's paper, material of that genus, obtained from the Philippine Islands and the Arabian Sea off Quilon (Kerala State), India, has been examined and compared with specimens of *carnolabrum* from the South China Sea. In view of the close agreement in meristic characters and overall morphology between the new material and that from the South China Sea, we conclude that all of the specimens of this genus examined are conspecific. Based on our studies of three of the paratypes and new material of *carnolabrum* and on the original descriptions, modified and updated descriptions of the genus and species and comments on relationships are presented. The name *Tangia* is preoccupied. Herein, we propose a replacement name.

The following abbreviations are used: BMNH, British Museum (Natural History), London; SIO, Scripps Institution of Oceanography, University of California, San Diego; USNM, U.S. National Museum of Natural History, Washington, D.C.; and ZSI, Zoological Survey of India, Calcutta.

Lipocheilus, new name

Tangia Chan, 1970:19–20 (type-species *Tangia carnolabrum* Chan, 1970, by original designation). Preoccupied by *Tangia* Stål, 1859, a genus of Hemiptera.

Description: Mouth nearly horizontal, terminal. Jaws almost equal in length. Lower jaw exceeded anteriorly by upper when mouth closed. Anterior end of upper lip of adults with thick, fleshy protrusion (Chan, 1970:23, pl. 1). Premaxillaries protractile. Maxillary scaleless and without series of ridges. Two narial openings on each side, close to each other and to eye. Interorbital region transversely somewhat flattened to slightly convex. A rather blunt projection (spinous in some specimens) at posterior end of bony opercle, dorsal to this on opercle a rounded bony projection. Gill openings extending somewhat anterior to a vertical from anterior border of orbit. Gill arches four, a slit behind the fourth. Pseudobranchiae present. Dorsal fin continuous and not incised at junction of spiny and soft portions. Spines of dorsal and anal fins robust, extremely well developed in large adults. Last dorsal and anal soft rays not produced, shorter than penultimate rays. Pectoral fin long. Caudal fin forked, but lobes not produced into filaments. Scales ctenoid. Cheek, postorbital region, proximal concave border of preopercle, opercle, subopercle, and interopercle with scales. A patch of scales in temporal region separated from postorbital scales below and dorsolateral scales of body above by narrow naked areas running obliquely posteriorly and ventrally from scaleless interorbital region. Snout, preorbital, interorbital, narrow zone immediately ventral and posterior to eye, maxillary, lower jaw, most of preopercle, and gular region without scales. Dorsal and anal fins scaleless except a few scales basally at posterior end of each fin. Pelvic axillary process present. Pectoral and caudal fins scaly basally. Lateral line complete, sensory tubules simple. Pelvic-fin rays 1,5. Principal caudal-fin rays 17 (9 + 8), procurent rays 11 dorsally and 11 ventrally. Branchiostegal rays 7 (2 articulating with epihyal, 5 with ceratohyal, arranged in two groups—an anterior group of 3 inserting along ventral edge of hyoid arch and a posterior group of 4 inserting laterally on arch). Vertebrae 24 (10 precaudal + 14 caudal). Three predorsal bones, anterior neural spines, and anterior dorsal pterygiophores in “*Lutjanus*-configuration” (Heemstra, 1974:23, fig. 4). Other characters those of the single species.

Etymology: The name *Lipocheilus* is from the Greek (*lipos*, fat; *cheilos*, lip) referring to the fleshy protrusion of the upper lip of adults of this genus. The gender is masculine.

Lipocheilus carnolabrum (Chan)

Figure 1; Tables 1 and 2

Tangia carnolabrum Chan, 1970:20–23, 27–33, pl. 1, figs. 1–9c, tables 1 and 2 (original description and illustrations; holotype BMNH 1969.3.24.76, 378 mm SL; type-locality ca. 145 km southeast of Hong

Kong in the South China Sea). Senta and Tan, 1975:21 (Andaman Sea).

Description: Chan (1970:22–23, figs. 1–9c) presented a description and illustrations of the osteology. The variable meristic data and selected morphometric data are given in Tables 1 and 2. Differences evident in Table 1, particularly those for gillrakers, lateral-line scales, and caudal-peduncle scales, may signify geographic variation. The variations shown in Table 2 by certain morphometric characters are apparently in large part due to allometric growth.

Dorsal-fin rays X,10. Anal-fin rays III,8. Two dorsalmost and the ventralmost pectoral-fin rays unbranched, other rays of pectoral fin branched. Fleishy protrusion at anterior end of upper lip well developed in adults, apparently developing in juveniles. Posterior end of maxillary reaching vertical through middle of eye. Posterior border of anterior nostril with flap of tissue which when reflected reaching to or very near posterior narial opening. Anterior narial opening usually rounded. Posterior narial opening elliptical, in adults notably larger than anterior opening, quite narrow posteriorly (sometimes almost a slit). Posterior-most point of head reaching a vertical through at least base of first dorsal spine (in one juvenile extending as far posteriorly as vertical through base of fourth dorsal spine). Premaxillary with an inner band of very small, essentially villiform, teeth and an outer series of conical teeth, a few of these at anterior end of jaw enlarged as canines; symphysis toothless. No teeth at symphysis of dentaries, but each dentary with patch of small (essentially villiform) teeth near symphysis, this patch extending posteriorly for some distance along jaw in adults; jaw with series of conical teeth on side beginning some distance back from anterior end and extending to rear; near anterior end of dentary two to four (frequently well exerted) canine to canine-like teeth. Vomer and palatine with villiform teeth, those on vomer in chevron-shaped patch with apex directed anteriorly, those on palatine in narrow, antero-posteriorly oriented band. No teeth on tongue or pterygoids. Preopercle serrate but without a spine at angle; vertical limb with fine serrae; serrae larger at angle; horizontal limb with fine serrae posteriorly, almost smooth to smooth anteriorly. Preopercular notch absent to slightly developed in adults, absent in juveniles. Margins of interopercle and subopercle essentially smooth. Body compressed, fairly deep, resembling that of *Apsilus*. Pectoral fin long, falcate in adults, reaching a vertical through base of second anal spine or beyond to as far as a vertical through base of fifth anal soft ray. Pelvic fin reaching a point just short of vent to as far posteriorly as first anal spine. First pelvic soft ray slightly produced in one juvenile. Anal fin rounded anteriorly; somewhat angulated posteriorly in adults. Predorsal scales beginning over posterior part of orbit. Scale rows above and below lateral line parallel to it.

In alcohol, one juvenile (Fig. 1) showing ground color of head darker than that of body; body with five dark vertical bars (about as dark as

TABLE 1. Meristic data for *Lipochaetus camolabrum*. Paratypes are denoted by an asterisk. Standard length is in mm. For bilateral counts, the left side is presented first.

Character	Arabian Sea				Philippine Islands	South China Sea		SIO75-409
	ZSI F 6569/2		ZSI F 7183/2		USNM 184520	USNM 203859*		
Standard length	111	113	208	218	285	438	440	445
Pectoral-fin rays	15, 16	15, 15	15, 16	16, 16	16, 16	16, 16	16, 16	16, 16
Gillrakers (including rudiments) :								
Upper limb	7, 7	6, 6	5, 6	6, 7	6, 6	6, 6	7	7, 6
Lower limb	14, 14	14, 14	13, 13	14, 14	13, 12	12, 13	13	12, 12
Total	21, 21	20, 20	18, 19	20, 21	19, 18	18, 19	20	19, 18
Tubed lateral-line scales	49, —	49, 50	51, 50	49, 50	51, 52	51, 51	51, 54	53, —
Scales above lateral line	—, 10	—, ca. 9	ca. 9, ca. 9	ca. 10, ca. 10	ca. 10, 10	9, 9	—, ca. 9	9, —
Scales below lateral line	ca. 18, —	ca. 18, —	ca. 18, —	ca. 18, —	18, ca. 18	17, 18	17, —	18, —
Cheek-scale rows	—, ca. 9	ca. 8, —	ca. 8, 8	ca. 9, ca. 9	9, —	8, 8	ca. 8, —	8, —
Predorsal scales	ca. 17	ca. 18	ca. 16	ca. 18	ca. 18	18	16	18
Caudal-peduncle scales	27	27	26	26	27	ca. 27	28	ca. 28
Scale rows between lat. line & mid-dorsal fin	6.0, 6.0	ca. 6.0, —	ca. 6.5, —	ca. 6.5, —	7.0, 7.0	6.5, 6.5	6.5, 6.5	6.5, 6.5

head)—one just posterior to opercle, one ventral to spiny dorsal fin, one ventral to soft dorsal fin, and two on caudal peduncle—all more prominent dorsally and dorsolaterally than ventrally (becoming almost imperceptible at midventral line). Bars for most part wider than interspaces; widest bar beneath spiny dorsal fin—at fin base extending from ca. fourth through tenth dorsal spine, but narrowing considerably below lateral line. Fins with a little dusky pigment, except pectorals mostly pale. Coloration of body and fins of adults directly after capture: yellow with tinge of brown on dorsum of head and anterior part of lips and silvery sheen on lower side of body (Chan, 1970:22–23, pl. 1). Preserved adults at larger sizes retaining no distinctive pattern of coloration, but two smaller adults (ZSI F 7183/2, 208–218 mm SL) showing three posteriormost vertical bars of juvenile pattern of coloration.

Distribution: Chan (1970) reported that *Lipocheilus carnolabrum* is a moderately common constituent of the long-line fishery on the continental shelf off south China. The holotype of *L. carnolabrum* (BMNH 1969.3.24.76) and four of the paratypes (BMNH 1969.3.24.75, 1969.3.24.77, 1969.3.24.78, and 1969.4.30.1) were collected in approximately the same area of the South China Sea as the paratypes (USNM 203859) examined by us, but at a shallower depth, 110 to 130 m (Chan, 1970). Chan (in litt., 29 January 1975) informed us that this species was fairly common in 1974 at Phuket, Thailand, on the Andaman Sea, and Senta and Tan (1975) reported it from the Andaman Sea in depths of 94 (94–110) to 130 (112–130) m. This species, then, is known from off the Philippine Islands and the South China, Andaman, and Arabian seas in depths of 94 (94–110) to 300 m.

Material examined: We examined nine specimens, 111–450 mm SL. PARATYPES: USNM 203859 (3 specimens, 438–450 mm SL); South China Sea, N. Vereker Bank, ca. 145 km southeast of Hong Kong; 130–145 m; captured by a Hong Kong long-liner over a bottom of dead shells and corals; obtained from Hong Kong Aberdeen Wholesale Fish Market, 26 May 1968. OTHER MATERIAL: USNM 184520 (1, 285 mm SL); Philippine Islands, Jolo Market; obtained by personnel from the ALBATROSS, 11 February 1908. SIO75-409 (1, 445 mm SL); obtained from Hong Kong Aberdeen Wholesale Fish Market. ZSI F 6569/2 (2, 111–113 mm SL); Arabian Sea, off Quilon (Kerala State), India, Lat. 8°45'N, Long. 75°50'E; 300 m; coll. by trawl, P. K. Talwar, 3 March 1971. ZSI F 7183/2 (2, 208–218 mm SL); same locality as ZSI F 6569 2; coll. by trawl, P. K. Talwar, 12 March 1975.

DISTINGUISHING CHARACTERISTICS AND RELATIONSHIPS

Adult *Lipocheilus carnolabrum* can be distinguished readily from other lutjanids by the thick, fleshy protrusion at the anterior end of the upper lip. Both juveniles and adults of this species are recognizable by the following combination of characters: upper jaw extending anteriorly beyond lower with mouth closed, maxillary without scales and without series

TABLE 2. Morphometric data for *Lipchoeilus canolabrum*. Paratypes are denoted by an asterisk. Standard length is in mm; other measurements are in percentage of standard length.

Character	Arabian Sea				Philippine Islands		South China Sea			
	ZSI F 6569/2		ZSIF 7183/2		USNM		USNM		203859*	
	111	113	208	218	285	438	440	450	445	445
Standard length	111	113	208	218	285	438	440	450	445	445
Head, length	45.3	44.2	44.2	44.9	37.0	35.5	36.9	35.6	35.5	35.5
Snout, length	12.6	11.1	14.4	15.1	14.0	13.5	14.6	15.0	14.6	14.6
Fleshy orbit, horizontal diameter	11.9	11.1	10.8	10.3	8.5	8.0	7.9	6.8	6.6	6.6
Postorbital length of head	22.7	21.7	21.6	21.1	16.0	15.8	16.6	16.0	16.0	16.0
Interorbital, least bony width	7.9	8.8	9.1	8.7	8.0	9.1	9.4	9.3	9.0	9.0
Suborbital, least width	4.1	3.5	4.3	4.4	5.5	5.3	6.6	5.8	6.2	6.2
Upper jaw, length	18.1	17.7	18.0	17.4	16.9	15.7	16.9	17.5	16.8	16.8
Lower jaw, length	20.7	21.2	19.7	19.5	18.3	17.5	17.9	17.6	17.1	17.1
Cheek, length	13.4	13.7	15.4	14.2	10.9	10.5	10.8	10.1	10.2	10.2
Body, depth	41.3	39.8	42.3	39.0	38.4	38.9	39.5	39.3	38.2	38.2
Predorsal length	45.7	42.9	43.3	43.1	41.6	40.0	41.8	40.7	40.2	40.2
Prepectoral length	42.5	39.4	39.4	39.4	34.6	33.6	35.6	34.4	34.6	34.6
Prepelvic length	44.6	41.6	44.2	42.2	41.3	38.9	39.5	39.3	39.5	39.5
Prealanal length	67.3	64.6	61.1	62.4	67.4	68.0	67.0	66.4	66.5	66.5
Caudal peduncle, length	19.5	20.4	19.2	22.9	22.2	22.3	21.5	21.7	20.6	20.6
Caudal peduncle, least depth	12.3	12.4	12.0	11.2	12.1	11.4	11.8	11.9	11.8	11.8
Dorsal base, length	46.3	46.0	47.6	46.3	47.4	47.9	48.9	48.4	49.2	49.2
Depressed dorsal fin, length	58.5	60.2	59.1	56.9	59.7	58.7	58.9	57.8	59.0	59.0
First dorsal spine, length	8.2	6.6	6.7	5.9	6.7	6.2	—	5.9	—	—
Third dorsal spine, length	17.2	13.7	14.4	13.8	—	14.4	16.8	16.0	14.9	14.9

TABLE 2, continued.

Character	Arabian Sea		Philippine Islands		South China Sea				
	ZSIF 6569/2	ZSIF 7183/2	USNM		U S N M	2 0 3 8 5 9 *		SIO75-409	
			184520						
Longest dorsal spine, length	18.0 (4th)	17.7 (4th)	15.4 (4th)	15.1 (4th)	17.6 (4th)	16.7 (6th)	18.2 (4th)	16.6 (4th)	16.5 (5th)
Last dorsal spine, length	13.7	11.9	11.5	11.9	13.8	12.5	13.1	12.4	13.0
First dorsal soft ray, length	ca. 14.6	13.7	12.9	14.2	14.5	13.2	13.8	13.6	13.7
Longest dorsal soft ray, length	16.2 (6th)	18.6 (5th)	15.4 (5th, 6th)	15.1 (5th, 6th)	—	14.9 (4th)	16.0 (4th)	15.2 (4th)	15.1 (4th)
Last dorsal soft ray, length	ca. 11.4	9.7	11.1	10.8	—	9.9	10.1	10.1	9.8
Anal base, length	16.9	16.8	16.8	15.6	16.8	17.0	17.7	16.6	16.7
Depressed anal fin, length	29.1	28.3	27.9	27.1	28.7	26.7	28.7	27.9	27.9
First anal spine, length	8.2	6.6	6.0	5.7	7.4	5.7	6.2	6.5	6.7
Second anal spine, length	13.2	12.4	10.8	10.6	11.1	9.6	9.9	9.6	10.1
Third anal spine, length	13.5	12.4	10.8	11.0	12.4	11.5	—	11.4	11.7
First anal soft ray, length	15.3	13.7	14.4	14.2	14.3	12.8	—	13.2	13.3
Longest anal soft ray, length	15.3 (1st)	13.7 (1st)	14.4 (1st)	14.7 (2nd)	14.3 (1st)	13.4 (2nd)	13.5 (2nd)	13.7 (2nd)	13.5 (2nd)
Last anal soft ray, length	—	11.9	10.8	10.6	11.6	10.2	10.5	10.8	10.7
Pectoral fin, length	—	30.9	—	36.7	36.2	34.2	36.3	32.7	33.6
Pelvic fin, length	26.4	23.4	23.1	22.9	24.7	22.4	24.8	23.0	23.1
Pelvic spine, length	15.3	13.3	13.5	13.3	15.5	14.1	14.6	13.6	14.2

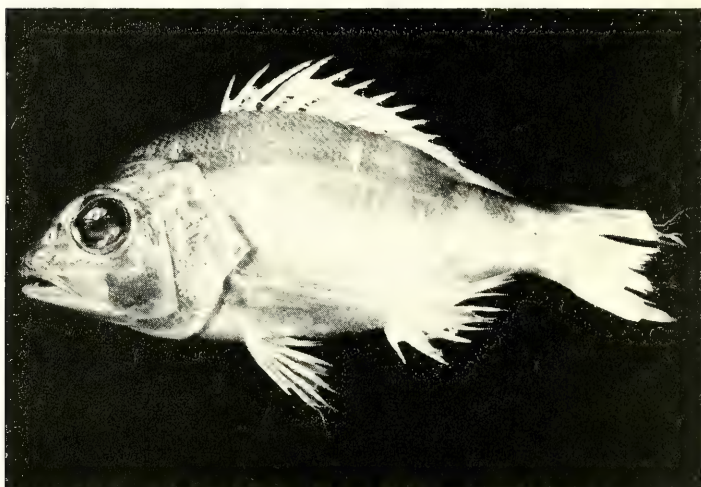


FIG. 1. Juvenile of *Lipocheilus camolabrum* (Chan), ZSI F 6569/2, 111 mm SL (right side photographed, negative reversed during printing).

of longitudinal ridges, anterior and posterior nostrils close together and to eye, interorbital region transversely somewhat flattened to slightly convex, vomer and palatines with teeth, no teeth on tongue or pterygoids, no molariform teeth, dorsal fin continuous and not incised at junction of spiny and soft portions, dorsal and anal fins essentially scaleless, anterior soft rays of dorsal and anal fins not elongated, last dorsal and anal soft rays not produced—shorter than penultimate rays, dorsal-fin rays X,10, pectoral fin long, caudal fin forked but lobes not produced, adults mostly yellow, juveniles barred.

Chan (1970) considered *Lipocheilus* as an eteline lutjanid. Except for the fleshy protrusion of the upper lip, *Lipocheilus* closely resembles its relative, *Apsilus* Valenciennes which is known from the Indian Ocean, Red Sea, and both sides of the Atlantic. *Lipocheilus* and *Apsilus* together with the Indo-west Pacific *Paracaesio* Bleeker form a natural group which is intermediate in several respects to the Etelinae and Lutjaninae. This group shares with the etelines naked dorsal and anal fins, closely approximated nostrils, an ectopterygoid without a posterior extension, and high numbers of trisegmental pterygiophores and procurent caudal rays, but also possesses a lutjanine type of neurocranium (without posterior frontal thickening forming a complete transverse ridge of demarcation anterior to the occipital region) and predorsal-bone configuration,¹ and

¹Two of eleven specimens examined of the western Atlantic species *Apsilus dentatus* Guichenot have the eteline configuration of predorsal bones (which is like that shown by Heemstra, 1974:23, fig. 4, except that the interdigitations of the predorsal bones and neural spines are altered so that the second and third predorsal bones are between the first and second neural spines).

like the lutjanines ultimate dorsal and anal soft rays which are shorter than the penultimate.

ACKNOWLEDGMENTS

Dr. S. Khera, Deputy Director-in-Charge, ZSI, encouraged this study. Shri M. C. Perumal, Director, Central Institute of Fisheries Operatives, Cochin, and Shri M. Devidas Menon, Director, Integrated Fisheries Project, Cochin, made available facilities aboard trawlers fishing in the Arabian Sea. Curators of the Division of Fishes, USNM, loaned us paratypes and provided space and facilities. Dr. W. L. Chan, Fisheries Research Station, Aberdeen, Hong Kong, furnished the specimen now deposited in the collections at SIO. Mr. B. M. Martin, Medical University of South Carolina, and Mr. James F. McKinney, USNM, made some of the radiographs used in this study. Mr. Joseph L. Russo, National Marine Fisheries, Systematics Laboratory, USNM, supplied Fig. 1. Mr. McKinney brought to our attention the preoccupation of the name *Tangia* and Dr. Chan very graciously allowed us to offer a replacement name. Drs. William R. Taylor and Stanley H. Weitzman (USNM) gave helpful comments on the manuscript.

This is contribution number 38 of the Grice Marine Biological Laboratory, College of Charleston.

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PROCEEDINGS
OF THE
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CORYPHAENOIDES DELSOLARI, A NEW SPECIES
OF MACROURID FISH FROM THE PACIFIC COAST
OF SOUTH AMERICA

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INTRODUCTION

Chirichigno-Fonseca (1968:418-421, fig. 13) described and illustrated an unusual 454 mm specimen of Macrouridae that was collected in about 300 m off the coast of Callao, Peru. The specimen had fine scale spinules that were tridentate at the tip, a condition previously unknown in macrourids. Although Chirichigno-Fonseca suspected that it represented an undescribed species, the uncertain taxonomic status of the specimen led her to list the species as "*Nematonurus* sp. aff. *altipinnis* Günther." In a later publication (1974) she listed the species as *Coryphaenoides* nov. sp. Subsequently, Iwamoto, who has been involved in a systematic review of all eastern Pacific Macrouridae, discovered many other specimens of the species in several United States museums. This distinctive new species is herein described.

METHODS

Methods for making counts and taking measurements generally follow procedures outlined by Hubbs and Lagler (1958) and modifications for macrourids by Gilbert and Hubbs (1916) and Iwamoto (1970). Head length (HL) is used for comparing most morphometric features, as opposed to the more commonly used standard length and total length (TL) which, in macrourids, are generally unsuitable because of the frequent loss of parts of the attenuated tail tip. A plus sign (+) in front of total length measurements indicates that part of the tail tip is missing.

Dorsal fin ray counts include all rays; the last ray is not split and we do not follow the procedure of counting the last two rays as one. Pectoral fin ray counts include the short, splintlike uppermost ray, which is usually closely appressed to the much longer adjacent ray. Vertebral numbers were counted from radiographs.

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Dr. D. M. Cohen, Systematics Laboratory, National Marine Fisheries Service, Washington, D. C. and Dr. W. N. Eschmeyer and Mrs. L. J. Dempster, California Academy of Sciences (CAS) reviewed the manuscript.

We thank Dr. Jorge Sánchez-R., former Director General Científico of the Instituto del Mar (IMARPE), for his assistance to research on Peruvian Fishery resources, which has contributed greatly to the progress of ichthyology in Peru.

Mr. J. E. Gordon made radiographs of the new species and Mrs. K. P. Smith drew the illustrations.

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***Coryphaenoides delsolari*, new species**

FIGURE 1-3

Nematomurus sp. aff. *altipinnis*: Chirichigno-Fonseca; 1968:418-421, fig. 13 [descr.; illus.]; 1969:37, fig. 81 [listed].

Coryphaenoides nov. sp. Chirichigno-Fonseca, 1974:315, figs. 622-624 [in key].

Holotype: USNM 215278 (87 mm HL, +390 mm TL), off Ecuador, 03°15'S, 80°55'W, 945-960 m, 72-ft otter trawl, 10 Sept. 1966, ANTON BRUUN Cruise 18B, Sta. 770.

Paratypes (36 specimens, 23-107 mm HL, +92-510 mm TL): Cocos Is., 97 km S: AMNH 7514 (1, 61 HL, +250 TL), 04°50'N, 87°00'W, 940-1646 m, 25 May 1925, ARCTURUS Sta. 74. Galápagos Is.: USNM 135922 (1, 84, +360), 19 km E of Hood Is., 01°35'S, 89°30'W, 1158 m, 7 Nov. 1904, ALBATROSS Sta. 4641. CAS 34288 (1, 23, 115), 27 km

SSE of Isla San Cristóbal, 01°06'S, 89°22'W, 700–800 m, 12 Aug. 1968, TE VEGA Cruise 19, Sta. 102. Ecuador: IMARPE 66-2222 (1, 72, +310), MCZ 51524 (1, 72, +345), and CAS 34289 (8, 40–107, 182–510), capture data same as holotype. Peru: USNM 150187 (1, 81, 375), Point Aguja, 05°47'S, 81°24'W, 980 m, beam trawl, 12 Nov. 1904, ALBATROSS Sta. 4653, LACM 33876 (2, 93–101, +350–+400), near Lobos de Afuera Is., 07°07'S, 80°46'W, 1200 m, beam trawl, 20 Jan. 1974, Cruise 7401, Sta. SNPI-13, IMARPE 74-2218 (3, 69–91, 294–388), 07°07'S, 80°46'W, 1200 m, modified Agassiz trawl, 20 Jan. 1974, E. del Solar. CAS 34290 (4, 38–58, +140–+225), IMARPE 66-2221 (1, 49, +180), 07°49'S, 80°38'W, 605–735 m, otter trawl, 5 Sept. 1966, ANTON BRUN Cruise 18B, Sta. 754, IMARPE 71-982 (1, 85, 396), 10°00.5'S, 79°11'W, 800 m, modified Agassiz trawl, May 1971, Juan Vélez. IMARPE 71-932 (2, 58–66, 245–286), 10°51.8'S, 78°30.7'W, 800 m, modified Agassiz trawl, 15 May 1971, Juan Vélez. IMARPE 58-981 (1, 93, 454), off Callao, 300 m, 1958, Martínez. CAS 28765 (1, 27, +107), 13°S, 76°W, 700–704 m, 25 Jan. 1972, IMARPE 72-977 (1, 89, 385), 13°57.2'S, 76°42'W, 600 m, 7 Aug. 1972, M. Méndez. CAS 28766 (1, 26, +92), 17°43'S, 71°42.5'W, 650 m, 27 Jan. 1972, CAS 28767 (1, 92, +267) and IMARPE 72-2220 (1, 81, 375), 18°10'S, 71°29'W, 610 m, 21 Aug. 1972, M. Méndez. Chile: CAS 34291 (2, 36–38, 165–165), 32°17'S, 71°39.5'W, 580 m, 72-ft otter trawl, 11 Aug. 1966, ANTON BRUN Cruise 18A, Sta. 702, CAS 34292 (1, 39, 187), 32°08.5'S, 71°43'W, 960 m, 72-ft otter trawl, 12 Aug. 1966, ANTON BRUN Cruise 18A, Sta. 703.

Diagnosis: A species of *Coryphaenoides* (subgenus *Coryphaenoides*) with head and body scales densely covered with fine, relatively erect spinules, most with multipronged, usually tridentate, tips (Fig. 2) in adult specimens larger than 50 mm in head length. Almost all of head and body uniformly scaled, including essentially all of snout, suborbital region and rami of lower jaws, but not including the exposed surface of the interopercle and the branchiostegal membrane. Pelvic rays 9–10 (rarely 11). Medial gill rakers on first (outermost) arch 1–2 + 9–12 (11–14 total); on second arch 1–2 + 9–11 (10–13 total). Mouth moderate in size; upper jaw 2.4–2.9 into head. Orbits large, 2.9–3.4 into head, 0.9–1.1 into interorbital space. Barbel short and very thin, usually 4 or more into orbit diameter, more than 10 into head. Teeth small, in moderately broad band in upper jaw with outer series slightly enlarged; in narrow band on lower jaw (band broader at symphysis).

Counts and measurements: Fin ray and gill raker counts are tabulated in Table 1. Total length of specimens examined +92–510 mm; head length 23–107 mm. The following measurements are in percent of head length: postrostral length of head 70–79; snout length 26–32 (38 in smallest juvenile); preoral length 13–24; width between supranarial ridges 20–25; orbit diameter 23–34; interorbital width 23–32; postorbital length of head 38–50; distance orbit to angle of preopercle 42–50; suborbital width 12–17; upper jaw length 35–41; preanal length 128–164; distance outer pelvic ray to anal origin 28–53; distance isthmus to anal

TABLE 1. Frequency distributions of selected meristic characters of *Coryphaenoides delsolari*.

	9	10	11	12	13	14	\bar{x}
First dorsal fin rays	—	5	19	4	1	—	11.03
Pelvic fin rays*	30	27	1	—	—	—	9.50
Medial gill rakers on:							
first arch	—	—	5	17	5	1	12.07
second arch	—	2	15	11	—	—	11.32
	19	20	21	22	23	24	\bar{x}
Pectoral fin rays*	1	6	10	13	20	5	22.09

* Fin ray counts (doubled) taken from fins of both sides.

origin 60–91; greatest body depth 58–87; depth over anal origin 44–70; interspace between first and second dorsal fins 13–45; height first dorsal fin 50–66; length pectoral fin 53–67; length pelvic fin 38–57; length barbel 3–10 (usually 4–6); length first (outer) gill slit 11–17.

DESCRIPTION

General features: The head of *Coryphaenoides delsolari* (Fig. 1) is large, deep, and relatively broad in juveniles but somewhat more laterally compressed in adults. Snout strongly pointed in juveniles but becomes blunt in adults; its dorsal median ridge with a high arch giving characteristic profile to snout in both young and adult. This median snout ridge enters into interorbital space leaving a shallow trough on either side. Interorbital space is broad; its width shorter than orbit diameter in young but greater than orbit diameter in large adults. Suborbital region relatively flat, but broad, bony, shelflike upper portion distinctly set off from soft, nonbony lower portion. Posterior (vertical) and ventral (horizontal) margins of preoperculum form a broadly acute angle; ridges on bone form a prominent lobe at their angle. Interopercle exposed posteriorly as a triangular tab. Mouth large; opening little restricted laterally and extends posteriorly almost under anterior edge of pupil. Maxillary extends posteriad to below posterior half of orbit. Barbel very thin and short; its length goes 2 to 3 times into suborbital width, only slightly greater than length of posterior nostril. Opercular opening relatively wide, with gill membranes broadly attached to isthmus and free posterior fold over isthmus virtually lacking. Five to 7 padlike lateral gill rakers of first arch visible through short outer gill slit. Rakers on medial side of arch more tubercular in shape, with 1–2 on the upper limb and 9–12 on the lower limb (total rakers 11–14). Raker count on

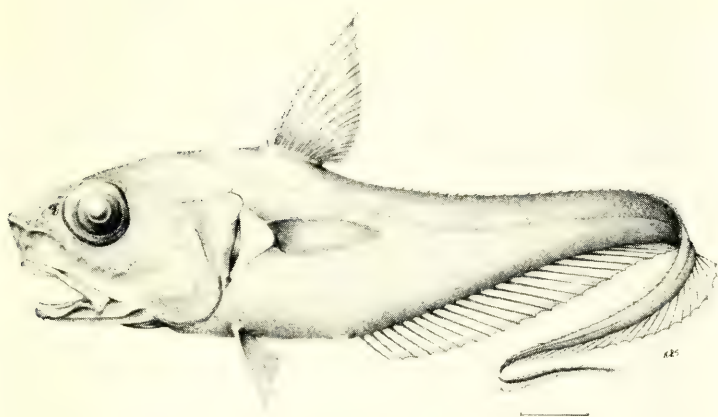


FIG. 1. Holotype of *Coryphaenoides delsolari* Chirichigno and Iwamoto, USNM 215278, 87 mm in head length, from off Ecuador in 945–960 m. Scale represents 25 mm. Drawn by Katherine P. Smith.

medial side of second arch 1–2 + 9–11 (10–13 total). Twelve precaudal vertebrae counted (by radiographs) in 2 specimens.

Fins: First dorsal fin rather low; its greatest height much less than postrostral length of head. First spinous dorsal ray spikelike; second elongated, with small, closely set teeth along leading edge. Midbase of pectoral fin about on midlateral line; length of fin more than half head length. Pelvic fin rather small, with outer ray prolonged into filamentous tip extending slightly beyond anal fin origin.

Teeth: Upper jaw teeth small, arranged in a broad band, with a slightly enlarged outer series. Lower jaw teeth very small, in a narrow band.

Squamation: Almost all parts of head and body uniformly scaled. All of snout and suborbital region scaled except narrow strip along ventral margins. Rami of lower jaw scaled. Gular membrane of large (445 mm TL) specimen (CAS 34289) with median patch of small, deciduous, spinulated scales; membrane naked in all other specimens. Branchiostegal membrane, exposed portion of interopercle, and shoulder girdle beneath gill covers naked. Scales on trunk and tail densely covered with slender, relatively erect spinules arranged in irregularly divergent rows. In large specimens (greater than about 80 mm HL), most scales have narrow, lanceolate spinules with tridentate or multipronged (as many as 5) tips (Fig. 2). In smaller specimens (50–80 mm HL) tridentate

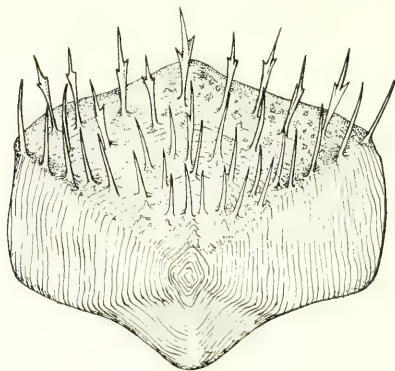


FIG. 2. Scale of *Coryphaenoides delsolari* from flank below the interspace between the first and second dorsal fins. Drawn by Katherine P. Smith.

spinules sparse but developed to various degrees. In even smaller specimens (less than 50 mm HL), spinules few, conical, and with slender, sharp, recurved tips. Well-developed terminal scute, and 2 less developed lateral scutes on snout. Scales dorsally on suborbital region deeply embedded and somewhat more coarsely spinulated than those ventrally. Scale rows (including the small ones at the base of the first spinous ray) below origin of first dorsal fin 8–12, $4\frac{1}{2}$ –8 rows below middle of fin, and 6–9 rows below origin of second dorsal fin. Lateral line scales 36–44 counted posteriad from shoulder girdle over distance equal to predorsal length.

Alimentary canal: The configuration of the alimentary canal (Fig. 3) agrees with that of *Coryphaenoides nasutus*, as figured by Okamura (1970:Fig. 63C), except that relatively few of the 11–14 short pyloric caeca are directed antieriad (supposedly characteristic of the subgenus *Coryphaenoides*)—most are directed posteriad.

Gas bladder: The large gas bladder is filled with spongy lipoidal matter that is characteristic of many macrourids. A well-developed oval area is situated dorsally. There are 4 long, slender retia (in a multiply coiled or looped arrangement), each connected to a small, peltate gas gland.

Color in alcohol: The overall ground color of medium to large individuals is dark brown, while the fins, gill membranes, and lips are brownish black. Linings of the oral, buccal, branchial, and abdominal cavities are blackish. Young individuals are generally paler in color than adults.

Etymology: The species is named in honor of Dr. Enrique del Solar in recognition of his numerous contributions to Peruvian ichthyology.

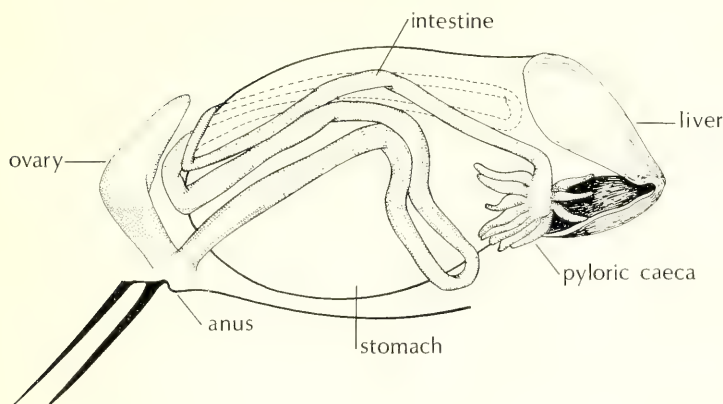


FIG. 3. Diagrammatic illustration of alimentary canal of *Coryphaenoides delsolari* showing coiling pattern of intestine and positions of certain organs. Drawn by Katherine P. Smith.

COMPARISONS AND RELATIONSHIPS

Coryphaenoides delsolari appears to be most closely related to *Coryphaenoides altipinnis* Günther, 1877, a species found off Japan known only from the holotype (the two small 6-inch specimens of the type series mentioned by Günther (1887:139) represent a species of *Nezumia*). We have not examined the holotype of *C. altipinnis* but from Günther's excellent illustration we note several distinct differences between that species and *C. delsolari*. *C. altipinnis* appears to have: (1) a larger barbel that enters about 1.2 times into the suborbital width compared with about 3 in *delsolari*; (2) a narrower suborbital region (about 2.5 into orbit compared with about 1.8 in *delsolari*); (3) a larger posterior nostril (length about 1.2 into suborbital compared with about 3 in *delsolari*); and (4) the scale spinules lack multipronged tips, appearing coarser, situated in distinct radiating, ridgelike rows, especially on the opercle, in contrast to the finer spinules not in distinct ridgelike rows in *delsolari*. *C. altipinnis* also appears to have a narrower suborbital shelf and a lower pectoral fin, the upper edge of which lies below the midlateral line, in contrast to well above the midlateral line in *delsolari*.

C. delsolari also resembles the Philippine species *C. orthogrammus* (Smith and Radcliffe, 1912) in many features, but *orthogrammus* has a more pointed snout, which is naked ventrally, and it lacks the peculiar tridentate scale spinules of *delsolari*.

Of the eastern Pacific species of macrourids, *C. delsolari* is likely to be confused only with *C. bucephalus* (Garman, 1899) with which it shares a generally similar physiognomy, dentition, and fin ray counts.

The new species can be readily distinguished from *bucephalus* by its higher gill raker count (11–14 total on medial side of first arch, compared with 9–10 in *bucephalus*), its much shorter barbel (more than 10 in head compared with less than 10 in head in *bucephalus*), its longer outer gill slit (11–17 percent of head length compared with 8–9 percent in *bucephalus*), and its distinctive scale spinules.

C. delsolari is readily distinguished from other members of the genus found off Peru and nearby waters by its distinctive scale spinules and the following: from *C. carminifer* (Garman, 1899) and *C. acrolepis* (Bean, 1884) by its higher pelvic fin ray count and shorter barbel; from *C. ariommus* Gilbert and Thompson, 1916, by its wider outer gill slit, more numerous gill rakers, and longer upper jaw; from *C. armatus* (Hector, 1875) by its dentition, larger orbit, shorter barbel, and more broadly scaled snout; from *C. capito* (Garman, 1899) (*Macrurus leucophaeus* Garman, 1899 and *M. boops* Garman, 1899 are probably synonyms) by its less restricted mouth (opening extends to anterior edge of orbit in *capito*, to pupil in *delsolari*), broader interorbital space (14–21 percent HL in *capito*), and longer, more lobate preopercle (distance orbit to angle of preopercle 31–35 percent HL in *capito*); from *C. fernandezianus* (Günther, 1887) by its more widely scaled snout and its dentition; from *C. liraticeps* (Garman, 1899) (*Macrurus anguliceps* Garman, 1899 and *M. latinasutus* Garman, 1899 are probably synonyms) by its wider outer gill slit, more numerous gill rakers, longer upper jaw, and more numerous pelvic fin rays.

DISTRIBUTION

The species is known from collections made on the Cocos Ridge, 97 km south of Cocos Is., off the Galapagos, off Ecuador, and southward through Peru to central Chile at latitude 32° south, in depths of 580–1200 m.

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PROCEEDINGS
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A REVIEW OF THE CRESTED TINAMOUS
(AVES: TINAMIDAE)¹

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Service, Washington, D.C. 20240*

From 1964 to 1967 biologists of the U.S. Fish and Wildlife Service conducted field studies on several species of tinamous in Argentina (Bump, 1969, Bohl, 1970). Some 300 specimens taken in the course of these studies were deposited in the U.S. National Museum of Natural History (USNM). The species best represented in this new material were among those previously most poorly represented in the USNM collection, and many birds were from parts of Argentina whence few specimens had been reported in the literature or examined by systematists. Attempts to identify and curate the large series of Crested Tinamous, *Eudromia elegans*, led to this review of variation in that genus.

Most recent studies agree that *Eudromia* includes two polytypic species, which Short (1975) considers a superspecies. *Eudromia elegans* is virtually endemic to Argentina, with only single localities known from Chile and Bolivia. *Eudromia formosa* is found in the chaco region of northern Argentina and Paraguay. In his review of the genus, Conover (1950) examined 87 specimens, which he allotted to eight forms, seven races of *elegans* and one monotypic species. Olrog (1959) based a further revision mainly on newly taken material in Argentina, and recognized eight subspecies of *elegans* and two of *formosa*. In this study I have been able to examine 196 specimens. I follow Olrog (1959) in recognizing the subspecies *formosa* and *mira* in *E. formosa*, and recognize and name

¹ This paper is dedicated to Alexander Wetmore on his ninetieth birthday, 18 June 1976.

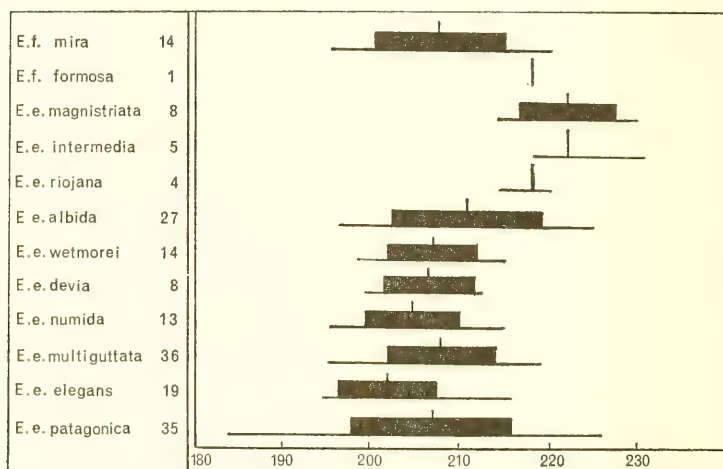


FIG. 1. Wing lengths of subspecies of *Eudromia elegans* and *formosa*. Each vertical line indicates mean of sample; each black rectangle is one standard deviation on either side of the mean.

here two additional races of *E. elegans*. The available material permits a comprehensive analysis of the distribution of the southernmost forms, although additional material will be needed before the ranges of the northern forms can be set forth in more precise terms.

PATTERNS OF VARIATION

Olog (1959) and Short (1975) have both pointed out that there are two well-defined groups of subspecies in *E. elegans*. The southern populations (*patagonica*, *elegans*, *multiguttata*, *numida*, *devia*, *wetmorei* and *albida*) are generally darker in overall coloration, have small spots dorsally, are more extensively barred abdominally, are more finely vermiculated, and have relatively short wings (Fig. 1). More northerly birds (*riojana*, *intermedia* and *magnistriata*) have wings about 10% longer, are generally paler, and have less extensive ventral barring although individual markings are bolder and broader. The dorsal marking tends to blotching rather than spotting. The race *albida* is somewhat intermediate between the two groups of races in respect to both wing length and general

coloration, although more closely allied to the southern group. The race *magnistriata* is also somewhat intermediate in color pattern, but closer to the northern group of *riojana* and *intermedia*. Further detail is given in the accounts of the subspecies.

The major break between the two subspecies groups of *E. elegans*, i.e. between *albida* and *riojana* (Fig. 2), seems to be along the border of the provinces of San Juan and La Rioja, probably along the valley of the Rio Bermejo. There are too few specimens from this probable contact zone to permit speculation on the nature of the contact of the subspecies groups. Interestingly, the Rio Bermejo and its tributaries were believed to represent a barrier between subspecies of another tinamou, *Nothoprocta pentlandii*, by Banks and Bohl (1968), who noted that the country south and west of that river is considerably more arid than it is to the north and east.

The trends toward increased mottling, rather than spotting, and bolder barring continue to the northeast from *E. elegans* to *E. formosa*, although trends of overall coloration and extent of ventral marking are reversed. Thus, the races of *E. formosa* are dark and heavily marked. The race *mira*, at least, is small, like the *E. elegans* races at the opposite end of the geographic range.

REMAINING PROBLEMS

As noted above, there are still too few specimens from the northern part of the range of *Eudromia* to permit accurate definition of the subspecific, or even specific, boundaries. *Eudromia formosa*, apparently confined to the relative lowlands of the chaco (Short, 1975), probably meets or overlaps with *E. elegans intermedia* throughout the province of Salta, along the foothills of the Andes. The two species seem to be nearly, if not actually, sympatric in northwestern Santiago del Estero and eastern Tucuman, at or near the type-locality of *E. formosa*. The nature of the interactions of the species in this extensive presumed contact zone remain unknown. Also unknown is the contact between *E. f. formosa* and *E. f. mira*, if indeed they prove to be different.

The lack of specimens from most of the provinces of Cor-

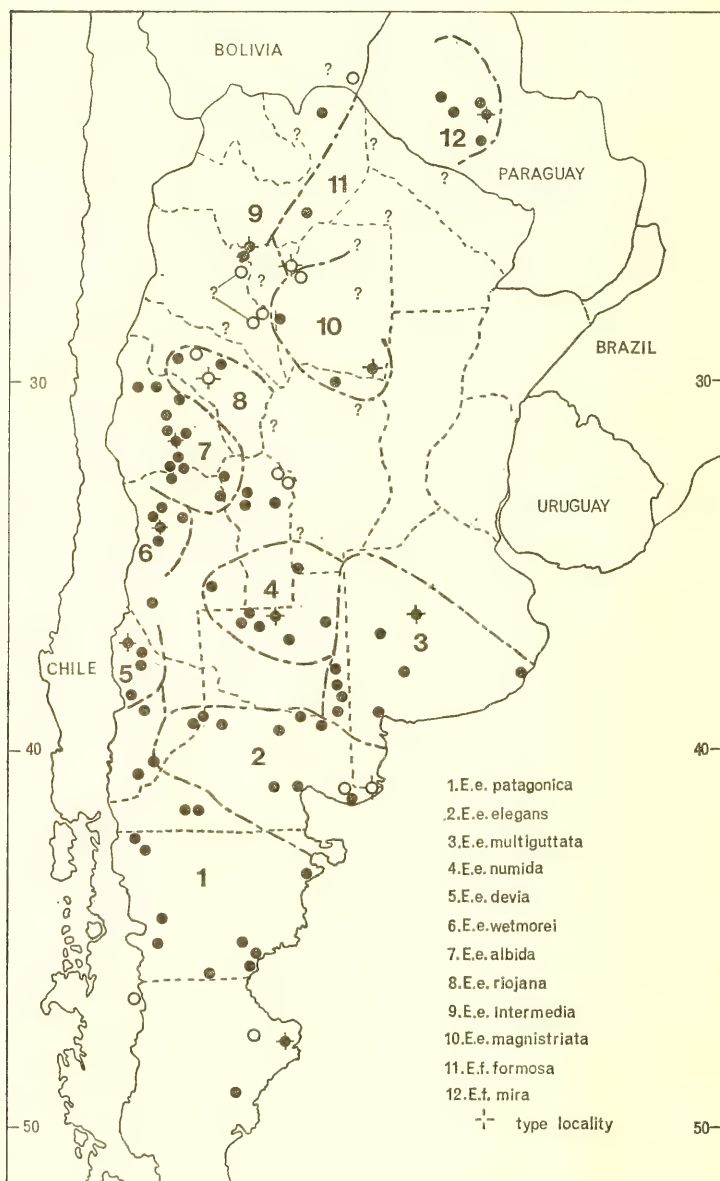


FIG. 2. Distribution and approximate subspecies boundaries of *Eudromia elegans* and *E. formosa*. Dots represent localities from which specimens were examined; circles are other reported localities. Two localities named "San Jose" in Catamarca are joined by lines and a query.

doba and San Luis reflects either a gap in the range of *E. elegans* or a paucity of collecting activity, although I suspect it is the latter. Birds from this area would help in the understanding of limits and contacts of a number of subspecies.

Three specimens from the north-central part of the Province of San Luis cannot satisfactorily be associated with any of the recognized forms. Although geographically closest to *E. e. albida*, they are quite distinct from that race in color characters. One bird, from 30 km S Rio Socoscora along route 146, at 2500 ft. elevation, strongly resembles specimens of *magnistriata* from Lavalle in the width of the ventral barring, but is darker and more olivaceous dorsally. There is some resemblance to *numida* dorsally but the bird is darker and the ventral surface is less extensively though more boldly barred. A second specimen, from 22 mi. N San Luis city on rt. 146, 2300 ft., is lighter and more buffy than the Rio Socoscora bird and is much more rufescent on the abdomen and somewhat less broadly barred ventrally. A young bird about one-third grown, from La Totorá, 2500 ft., is intermediate between the two adult birds. Steullet and Deautier (1935) mention two specimens under the name *morenoi* (= *elegans*) from Santa Rosa and Merlo, in the northeastern part of San Luis and at the northern end of the Sierra San Luis. There may be an undiagnosed population in eastern San Luis and Córdoba, between *numida* and *magnistriata*, to which these five problem specimens may be assigned.

EUDROMIA ELEGANS

Eudromia elegans patagonica Conover, 1950

Characters: Conover (1950) correctly characterized this form as dark olive gray dorsally, with prominent dark shaft streaks on feathers of the foreneck and chest. The shaft streaks of feathers of the hindneck are also more prominent than in other forms, and the ventral surface is more heavily and extensively barred.

Range: Southern Neuquén and southwestern Río Negro south through Chubut and Santa Cruz, Argentina, and adjacent Chile, from about 3000 feet elevation to the coast.

Discussion: Conover (1950) noted that all records available to him were from within 100 miles of the coast, and that he did not find tinamous near the Chile-Argentina border at 45°30'S, apparently in southern Chubut. Later two specimens taken at Chile Chico on the shore of Lago

Buenos Aires, Aysen, Chile (approximately 46°30'S), were referred to this subspecies (Johnson, 1965).

Newly acquired material shows that the range of this southernmost form is much more extensive than previously recognized. Specimens taken in the upland steppes of western Chubut cannot be distinguished from those from coastal localities studied by Conover.

On the basis of its presumably more buffy back a single bird from Collon Cura, Neuquen, was placed in *devia* by Conover (1950) who nonetheless mentioned its fully barred underparts and the broad dark shaft stripes of its chest feathers. Comparison with the newer material suggests that the dorsal coloration is much nearer that of *patagonica*, and any lessening of the olivaceous tones typical of that race is better interpreted as a tendency toward *elegans* than toward the even paler *devia*. The northern interior limit of *patagonica* is in the vicinity of Zapala, Neuquen; three birds from that locality are more buffy on the throat and breast and less heavily streaked than southern birds, but stand in sharp contrast to nearby *devia*.

One of two specimens placed with *elegans*, from 20 mi. NE Piedra del Aquila, Neuquen, shows tendencies toward the broad streaks of *patagonica*. A flat skin from Maquinchao and young bird from Huanuluan, Rio Negro, assigned to *elegans* by Peters (1923), show the broad shaft streaks on the neck and breast typical of *patagonica*, but the dorsal coloration of the adult is similar to *elegans*. These birds must indicate the general area in eastern Neuquen and in south-central Rio Negro where the two forms meet and intergrade.

Wing length: 183–226 mm; average of 35 specimens 207 ± 1.5 mm (S.D. 8.96). There is no difference between series of 16 inland and 19 coastal birds.

Specimens examined (38): NEUQUEN: Zapala (3, AMNH); Collon Cura (1, FM). RIO NEGRO: Maquinchao, 2900 ft. (1, MCZ); Huanuluan, 3100 ft. (1, chick, MCZ). CHUBUT: Cushamen, E of El Maiten, 1800 ft. (1, USNM); El Maiten (1, FM); 5 mi. E Leleque, 1800 ft. (3, USNM); 6 km S Nueva Lubecka, 2000 ft. (2, USNM); Alto Rio Senguerr, 2000 ft. (3, USNM, 2, LSU); Rawson, 300 ft. (3, FM); Rio Chico (1, FM); Caleta Cordoba [80 km N comodoro Rivadavia, *vide* A. Kovacs] (2, LACM, 2, ROM); Rivadavia (2, FM); Vale del Lago Blanco, Colhué Huapi (5, BMNH; 2, AMNH). Santa Cruz; Estacion Pampa Alta, Ferrocarril Patagonica, 600 ft. (1, type, FM); Est. Roco Blanco, Department Magallanes (2, AMNH).

Other localities: SANTA CRUZ: Aguada Grande (Dabbene, 1923); Bahia del Fondo (not mapped, Steullet and Deautier, 1935). CHILE: Aysen; Chico (Johnson, 1965).

Eudromia elegans elegans Is. Geoffroy, 1832

Characters: Light brownish-gray dorsally, lighter and grayer than *multiguttata*, browner than *patagonica*; grayer than forms to the northwest, with abdomen more heavily barred.

Range: From eastern Neuquen through most of the Province of Rio Negro and extreme southern Buenos Aires. Generally bounded on north by the Rio Colorado; southern borders uncertain, especially in eastern portion of range.

Discussion: As Conover (1950) pointed out, birds from the western portion of the range of *elegans*, in the vicinity of General Roca and Neuquen, tend to be slightly grayer than those nearer the coast, a tendency he attributed in part to wear. I agree with Conover (*op. cit.*) that *morenoi* (Chubb, 1917) must be considered a synonym of *elegans*. The type of *morenoi* is a very worn, gray bird, but others from near the type-locality, Neuquen, are as brown as coastal birds. The nature of the contact of *elegans* and *patagonica* has been discussed under the account of the latter. One of two specimens from near Piedra del Aquila is typical of *elegans*; the other shows tendencies toward *patagonica*.

Birds from the vicinity of Tunuyan, Mendoza, have been placed in *elegans* by various authors but the material now available clearly shows this to be erroneous. Conover's (1950) inclusion of the Tunuyan specimens in *elegans* caused him to overstate the range of the subspecies and necessitated awkward wording which Olrog (1959, 1963) apparently misinterpreted.

Some of the new specimens permit an evaluation of the contact of *elegans* and *multiguttata* in the eastern portions of Rio Negro and La Pampa, respectively. Here the Rio Colorado provides a barrier between the two subspecies, although apparently not an absolute one. A bird from 20 km west of the city of Rio Colorado, Rio Negro, is considered to be *elegans* although it approaches *multiguttata* in darkness of dorsal coloration. On the other hand, a bird from 40 km NE Rio Colorado City, La Pampa, is pale and gray dorsally like *elegans* but has the other features of *multiguttata*. Possibly fairly recent man-made changes in the valley have made the river a less formidable genetic barrier.

The boundary between *elegans* and *devia* to the northwest seems to be rather distinct, but there is a large area unrepresented by specimens.

Wing length: 194–215 mm; average of 19 specimens, 202.3 ± 1.33 mm (S.D. 5.79).

Specimens examined (19): NEUQUEN: 20 km W Neuquen (1, USNM); Blasa Las Perlas [nr. Neuquen?] (1, LSU); Neuquen (1, type of *morenoi*, BMNH); 20 mi. NE Piedra del Aquila, 1200 ft. (2, USNM). RIO NEGRO: General Roca (4, USNM); 6 km E Choele-Choel, 6000 ft. (1, USNM); Pichi Mahuida, 1800 ft. (3, FM); 20 km W Rio Colorado City, 400 ft. (1, USNM); Valcheta (1, MVZ); San Antonio (1, MVZ); mouth of Rio Negro (1, USNM); "Rio Negro, Patagonia" (1, BMNH); "Patagonia" (1, Brus).

Other localities: RIO NEGRO: Viedma (Steullet and Deautier, 1935). BUENOS AIRES: Bahia de San Blas (type-locality, *vide* Conover, 1950).

Eudromia elegans multiguttata Conover, 1950

Characters: Noted by Conover (1950) as being the darkest brown dorsally of the races, with reduced shaft stripes on feathers of the neck, mantle, and chest. Underparts dark, heavily barred.

Range: The Province of Buenos Aires, north of the Rio Colorado, and the extreme southeastern portion of La Pampa.

Discussion: The northern and northwestern limits of this race are poorly defined. Conover (1950) reluctantly included a specimen from Estancia La Primavera, Cordoba, northwest of the range as defined above, in *multiguttata*, but I have assigned it to another form.

Specimens newly acquired add little to our knowledge of this eastern subspecies. A series of eight birds from southeastern La Pampa tend variably toward the race *elegans*, particularly in development of the shaft streaks of the chest feathers, but in general are dark both dorsally and ventrally.

Chubb (1919) referred a specimen from Bonifacio, Laguna Alsina, Buenos Aires, to *E. formosa*, apparently believing the bird was from the Province of Cordoba, as did Liebermann (1936).

Wing length: 194–219 mm; average of 36 specimens, 208.3 ± 1.02 mm (S.D. 6.14).

Specimens examined (36): BUENOS AIRES: Mar del Plata (9, AMNH); Cambaceres (2, FM, type-locality); Bonifacio, Laguna Alsina (1, FM); D'Orbigny ea. San Pablo (3, AMNH; 2, LSU); Bahia Blanca (1, AMNH; 1, BMNH); Province of Buenos Aires (1, AMNH; 8, Denver). LA PAMPA: 40 km NW Buenos Aires-La Pampa border, Rt. 35 (1, USNM); 55 km S General San Martin, Rt. 154, 200 ft. (2, USNM); 2–3 mi. E Laguna Colorado Grande, on Rt. 154, 100 ft. (3, USNM); 40 km NE Rio Colorado City, Rt. 154, 400 ft. (2, USNM).

Eudromia elegans numida, new subspecies

Holotype: USNM 563103; male; west of Telen, La Pampa, Argentina, along Rt. 143 near km marker 287; coll. 28 May 1965, Wayne H. Bohl, original number 45.

Diagnosis: Light brown dorsally, lighter than *multiguttata* and less gray than *elegans*; similar to *multiguttata* in the reduction of shaft stripes of feathers of the neck, mantle, and chest, but neck paler and grayer than that form. Lighter, more buffy below than *multiguttata*, but abdomen darker than *elegans*. Darker and browner above, and darker below than populations to the northwest.

Range: Central and eastern La Pampa, southern Cordoba, southeastern Mendoza and probably southern San Luis.

Discussion: The extensive lists of specimens given by Conover (1950) mention only one bird from within the range of this subspecies, even though it occurs near the center of the species' range. Conover's (1950) inclusion of birds from Tunuyan, Mendoza (see beyond) in *elegans* resulted in an awkward statement of the range of that form which in-

cluded the large unknown area by default. The distribution of specimens still does not permit adequate definition of the range of *numida*.

Wing length: 195–215 mm; average of 13 specimens, 204.7 ± 1.49 mm (S.D. 5.38).

Specimens examined (13): CORDOBA: Estancia is Primavera (1, AMNH). LA PAMPA: Rt. 35, N Santa Rosa, 118 km S Realico (1, USNM); Rt. 143, W of Telen, near km marker 287 (1, USNM, type); 3–5 km E Emilio Mitre, Rt. 143 (1, USNM); 75 km W Victoria, Rt. 143, (2, USNM); 5 km E Santa Isabel (1, USNM). MENDOZA: ca. 35 km S General Alvear, Rt. 143 (1, USNM).

Etymology: Named for the guinea-fowl-like spotting dorsally.

Eudromia elegans devia Conover, 1950

Characters: Upper parts browner and buffier than *patagonica*, *elegans*, and *multiguttata*; paler and less heavily barred below than these races and *numida*, with a larger unbarred abdominal area. Neck grayer than in birds immediately to the north (see beyond) and abdomen less heavily barred.

Range: Western Neuquen and probably southwestern Mendoza.

Discussion: Conover (1950) included a bird from Collon Cura in this subspecies, noting its resemblance to *patagonica*. I have included that specimen in the expanded range of *patagonica*, further limiting the rather small range occupied by *devia*. The few new specimens of *devia* do not aid in the analysis of this form.

Wing length: 199–212 mm; average of 8 specimens, 206.7 ± 1.76 mm (S.D. 4.97).

Specimens examined (8): NEUQUEN: Chos Malal, 2500 ft. (3, incl. type, FM); 25 mi. N Churriaca, Rt. 40 (1, USNM); 4 km S Churriaca, and 114.8 km N Zapala, Rt. 40 (2, USNM); Las Lajas, 2000 ft. (2, FM).

Endromia elegans wetmorei, new subspecies

Holotype: USNM 285044; adult female; Tunuyan, Mendoza, Argentina; coll. 27 March 1921, Alexander Wetmore, original number 6354.

Diagnosis: Differs from *E. e. albida* to the north by being darker both above and below; ventral barring more extensive and ground color more rufescent. Differs from *devia* to the south in being darker below with more extensive barring on the lower flanks and abdomen, and darker and browner above, with the neck brown rather than gray. From *elegans*, *wetmorei* differs in the browner ground color of the breast, brown rather than grayish neck. Paler than *numida* ventrally, with heavier shaft streaking on breast feathers.

Range: Andean foothills of north-central Mendoza.

Discussion: As noted earlier, Conover (1950) placed birds from Tunuyan in *elegans*, though noting some plumage differences. In the fairly extensive barring of the abdomen, *wetmorei* does resemble *elegans*

and the other eastern lowland forms and represents an intrusion of this character between the plainer and paler *devia* and *albida*. The abdomen of *wetmorei* is darker than that of *elegans*, but is not as dark as in the intervening *numida*.

A single specimen from Malaraque, Mendoza, is geographically midway between the known ranges of *wetmorei* and *devia* and shares characters of these races although typical of neither. Wayne Bohl (pers. comm.) informed me that the population of *Eudromia* is low both north and south of Malaraque. He noted that Malaraque, at 4500 ft., is wetter than Chos Malal (*devia*) and is the coldest area in the range of *E. elegans*. Further, he said that Argentinians to whom he spoke considered the tinamous from that area to be large. The specimen available weighed 822 g, in contrast to 742 g and 750 g, respectively, for the heaviest *wetmorei* and *devia* taken by Bohl. Its wing length (209 mm) is typical of both races.

Wing length: 198–215 mm; average of 14, 207.2 ± 1.32 mm (S.D. 4.93).

Specimens examined (16): MENDOZA: La Ventana (1, USNM); near Manzano (1, USNM); 29 km S Tupungato (1, USNM); Tunuyan (7, FM; 2, USNM; 1, AMNH); Campo Los Andes (2, USNM); "Chili"= between San Raphael and San Carlos, 33°–34°S lat (Bridges, 1847) (1, BMNH).

Etymology: The name is a small token of my high esteem for Alexander Wetmore, who collected the holotype, who has made major contributions to our knowledge of Neotropical birds, including this species, and who encouraged me throughout this study.

Eudromia elegans albida (Wetmore, 1921)

Characters: Very pale above, with buffy to whitish spotting; unbarred abdominal area large and pale, rufescent buff to buffy white.

Range: Southern San Juan and extreme northern Mendoza provinces and adjacent San Luis.

Discussion: This race is much more variable, particularly in color of the underparts, than Conover (1950) could have realized from the few specimens available to him. It is markedly different from all forms discussed previously, except *devia*, in the reduction of barring on the lower flanks and abdomen and in overall paleness. It is similar to *devia* ventrally but paler above, and is separated from that race by approximately 500 km and the intervening *wetmorei*.

E. e. albida is considerably more barred ventrally than races to the north. A specimen from 7 km N Talacasto is nearly as unbarred abdominally as *riojana* but is like *albida* in other respects. These forms probably intergrade along the San Juan–La Rioja border, in the Rio Bermejo drainage. Three specimens from north of Desaguadero, on the Mendoza–San Luis border, are particularly pale and gray dorsally.

Wing length: 196–225 mm; average of 27, 210.7 ± 1.64 mm (S.D. 8.53).

Specimens examined (28): SAN JUAN: 50 km SE Iglesia (1, USNM); San Jose de Jachal, 3000 ft. (1, USNM); Agua de la Peña (2, AMNH); 7 km N Talacasto (1, USNM); Matagusanos (2, USNM); Angaco Sud (1, AMNH); San Juan (1, type, USNM); Canada Honda (2, FM); 8 km W Retamito, nr. Los Barros (1, USNM); 1 km E Retamito (1, USNM); 4 km NW Guanacache, 2500 ft. (2, USNM); 3 mi. W Guanacache, 2500–2600 ft. (3, USNM); 2½ mi. W Guanacache, 2000 ft. (1, USNM); San Juan–Mendoza border, approx. 45 km NW Jocoli, Mendoza, Rt. 40 (1, USNM). SAN LUIS: La Tranca, near El Retamo, Mendoza (5, USNM). MENDOZA: 29 mi. N Desaguadero (3, USNM).

Eudromia elegans riojana Olrog, 1959

Characters: Larger and paler than races to the south. The ventral bars are mainly restricted to the chest, only sporadically appearing on the lower flank feathers. Browner, less gray, than *intermedia*.

Range: Known only from central La Rioja.

Discussion: When Olrog (1959) described the present form he compared it mainly with *intermedia*, but he apparently reversed the forms when discussing the dorsal coloration. The three specimens from Villa Union, La Rioja, are much lighter dorsally, buff and brown, whereas those from Tucumán are darker and very gray. This is precisely opposite the characterization given by Olrog (1959). However, Olrog correctly stated that *riojana* has wider and darker bars on the breast feathers than *intermedia*; *riojana* also has a darker, browner neck.

There is a significant break in character between *albida* and *riojana*. Both *riojana* and *intermedia* are larger and have a much less barred abdomen than *albida* and the more southern populations.

The bird from Chilecito, La Rioja, allotted to *intermedia* by Dabbene and Lillo (1913), Conover (1950) and earlier authors, before *riojana* was described, undoubtedly belongs here. Similarly, an unspecified bird from La Rioja assigned to *formosa* (Conover, 1950) probably belongs here.

Wing length: 214–220 mm; average of 4 females, 218.0 ± 1.39 mm (S.D. 2.79).

Specimens examined (4): LA RIOJA: [La] Rioja (1, AMNH); 5–10 km W Villa Union, 3500 ft. (2, USNM); 20 km W Villa Union, 3500 ft. (1, USNM).

Eudromia elegans intermedia (Dabbene and Lillo, 1913)

Characters: Similar to *riojana* (q.v.) but much darker and grayer dorsally, with narrower bars on the chest and a grayer neck.

Range: Western Tucumán and adjacent northeastern Catamarca, northward through central and northern Salta into Bolivia.

Discussion: Conover (1950) assigned a specimen from San Jose, Catamarca, to this race; I have not seen that bird. There are at least two localities by that name in that province (Fig. 2), both near the border

with Tucumán. L. L. Short (pers. comm.) reports two specimens from Santa Maria, Catamarca, assigned to *intermedia*, in the Stockholm Museum. This locality is near the more southern San José. If properly identified, these birds indicate that the range of *intermedia* includes all of western Tucumán, and probably adjacent Catamarca. On the other hand, Santa Maria is not far from Lavalle, Santiago del Estero, and the birds in question may be *magnistriata*.

One specimen at hand, taken by G. Hoy, is labeled merely "Salta, 3500 m." This is presumably the bird that Hoy (1969) reported from near the Bolivian border of Salta, and is so plotted in Fig. 2, extending the range of *intermedia* far to the north.

A downy chick of *Eudromia* was taken 15 km NE Capirenda, Tarija, Bolivia, 4 August 1957 by Kenneth E. Stager and S. C. Bromley. I tentatively assign this bird to *intermedia* because of the proximity of the locality to that of Hoy's bird. This bird is only a few days old and exhibits no adult plumage on which an accurate specific, let alone subspecific, identification can be based. The locality is in the chaco of Bolivia and it is conceivable that the bird might represent an extreme westward range extension of *E. formosa mira* of the Paraguayan chaco or a northwestward extension of *E. f. formosa* of the Argentine chaco (see beyond for accounts of *E. formosa*).

Wing length: 218–231 mm; average of 5, 221.7 ± 2.46 mm (S.D. 5.50).

Specimens examined (6): SALTA: no specific locality, 3500 m (1, FM). TUCUMÁN: Colalao del Valle (2, FM); Amaicha del Valle (2, USNM). BOLIVIA: Tarija; 15 km NE Capirenda (1, chick, LACM).

Other localities: CATAMARCA: San Jose (Conover, 1950); Santa Maria, 1600 m (Stockholm Mus., *fide* L. L. Short).

Eudromia elegans magnistriata Olrog, 1959

Characters: As noted by Olrog (1959) this form has large spots dorsally and extremely wide bars on the breast. The dorsal background coloration is grayish brown as in *numida* to the south rather than the rich brown of *formosa* and in contrast to the sandy brown of *riojana* and *intermedia*.

Range: Southern Santiago del Estero, extreme northern Cordoba, and possibly adjacent Tucumán, Catamarca, and Santa Fe.

Discussion: Birds of this subspecies have been confused with *Eudromia formosa*, as discussed beyond under that species. *E. e. magnistriata* has the large dorsal spots and long wings of the *riojana-intermedia* group of subspecies, the grayish brown dorsal color and extensive abdominal barring of *numida* and the *elegans* subspecies group, and the very wide ventral barring of *E. formosa*. It thus blends the characters of populations on all sides of it, although it is least like the *formosa* I have seen, and the bold barring may merely reflect a similar adaptation to the chaco habitat.

A bird from Gutenberg, in extreme northern Cordoba, is similar dorsally to *magnistriata* from the type-locality and Lavallo, although it is somewhat paler. Ventrally, however, this bird resembles *numida* in both the extent and width of the ventral barring. This locality is at the edge of the chaco region and the bird may indicate a zone of contact between *magnistriata* and *numida* or represent some undescribed form occupying most of Cordoba.

Wing length: 214–230 mm; average of 8, 222.1 ± 2.05 mm (S.D. 5.81).

Specimens examined (8): SANTIAGO DEL ESTERO: Lavallo, 1800 ft. (4, AMNH; 2, FM); Pinto, Dept. Aguirre (1, AMNH, type-locality). CORDOBA: Gutenberg, Rio Seco (1, AMNH).

Other localities: SANTIAGO DEL ESTERO: Suncho Corral; Isca Iacu (Dabbene and Lillo, 1913, Olrog, 1959).

EUDROMIA FORMOSA

Eudromia formosa formosa (Lillo, 1905)

Characters: Differing from forms of *E. elegans* as does *E. f. mira* (q.v.) and similar to it. The single specimen seen is grayer than *mira* and has the shaft streaks of the back feathers narrow and well defined. Adequate characterization of the population must await additional material.

Range: Eastern Tucumán, eastern Salta, northern Santiago del Estero, and probably western Chaco and western Formosa, Argentina. The nature of the contact with *elegans intermedia* to the west and *e. magnistriata* to the south, and the relationship with *E. f. mira* to the north-east remain to be clarified, as do precise limits of the range.

Discussion: The original description of *formosa* is not particularly diagnostic of any *Eudromia*. The presumed new species was said to differ from *elegans* by having much larger black spots on the dorsum and the breast and by the distribution of the spots on the primaries. No type-specimen was designated and the type-locality was indicated merely as the plains of eastern Tucumán near the border of Santiago del Estero.

Dabbene and Lillo (1913) gave a more thorough description of *formosa*, presenting a detailed analysis of the male and comparative characters of the female and designating each the "type." Both birds were taken in 1905 by L. Dinelli. The male was from between Las Cejas, Tucumán, and Isca Iacu, Santiago del Estero, on the provincial border. The female was from Isca Iacu (this locality is called Isla Yacú on the only map on which I can locate it). Dabbene and Lillo (1913) included one or more birds from Suncho Corral, Santiago del Estero, with *formosa*. Peters (1931) accepted the male, first described, as the type and stated the type-locality as "between Las Cejas and Isca Iacu, Tucumán."

As Olrog (1959) has pointed out, Dabbene and Lillo (1913) introduced a certain confusion into the literature by describing both male and female of an essentially monomorphic species. Olrog (1959) has

shown on the basis of specimens in Argentine museums and the plates of Dabbene and Lillo that the two birds, male and female, were of different lineage, the male representing true *formosa* and the female, a form of *elegans* which he described under the name *magnistriata*. My analysis of limited specimen material, the plates, and written descriptions confirms Olrog's (1959) views, which also have been accepted by Meyer de Schauensee (1966).

The confusion regarding the true status of *formosa* (Peters, 1931, Hellmayr and Conover, 1942, Conover, 1950) was largely due to lack of specimens from northern and central Argentina at the time it was described and this problem remains unchanged, at least in North American museums. Dabbene and Lillo (1913) included birds from Suncho Corral, Santiago del Estero (now called *magnistriata*), with *formosa*. In the absence of true *formosa* in readily available collections, it was reasonable for Hellmayr and Conover (1942) and Conover (1950) to assume that AMNH specimens from Lavalle, in that province, even closer to Las Cejas and Isca Iacu, were *formosa*. Thus, *formosa* was considered to be a subspecies of *elegans*.

L. L. Short (pers. comm.) informs me that a Tucumán specimen in the Stockholm Museum has only traces of barring on the flanks and none on the lower breast and abdomen. This suggests a tendency toward the characters of *E. e. intermedia*.

Wing length: One specimen, 218 mm.

Specimen examined (1): SALTA: Cebalito [= Ceibalito], Dept. Anta (1, AMNH).

Other localities: TUCUMÁN: no specific locality (Stockholm Mus., *vide* L. L. Short; not plotted); between Las Cejas, Tucumán, and Isca Iacu, Santiago del Estero (type-locality).

Eudromia formosa mira Brodkorb, 1938

Characters: Differs from races of *E. elegans* by being mottled rather than spotted dorsally, with black and dark brown more prominent than buff; shaft streaks of dorsal feathers broaden terminally and blend with narrow dark bars on vanes; large dark brown patches on wing coverts; throat spotted rather than streaked; bars on chest and flank feathers expanding medially and appearing as sagittate blotches; inner vanes of primaries immaculate or finely vermiculated with buff. Presumed differences from *E. f. formosa* noted under that form.

Range: Known only from the Paraguayan chaco; perhaps extends into northern Argentina.

Discussion: The status of *E. formosa* was confused at the time Brodkorb (1938) described the population *mira*. His comparison of wing length of *mira* to that of *E. "elegans" formosa* was undoubtedly with Lavalle specimens, now referred to *E. e. magnistriata*.

Neither Conover (1950) nor Olrog (1959) had material of both *formosa* and *mira* forms for direct comparison. Eisenmann (*in* Meyer de

Schauensee, 1966:10) compared the two (presumably the few specimens in the AMNH) and considered *mira* possibly subspecifically distinct. With no additional material of *formosa* it is difficult to come to a more definite conclusion.

Wing length: 195–220 mm; average of 14 specimens, 207.7 ± 1.96 mm (S.D. 7.33).

Specimens examined (15): PARAGUAY: Orloff, near Islapoi (1, FM; 1, AMNH); 16 km E Philadelphia and 36 km N Islapoi (5, FM); 195 km W Puerto Casado (1, UMMZ); Aregua, 240 km W Puerto Casado (1, FM); 120 km W Puerto Pinasco (1, FM; 1, UMMZ; type-locality); Schopfurambu, Papil (1, FM); Lichtenau (3, incl. 1 chick, AMNH).

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I express my thanks to curators of the following institutions whose birds I was permitted to examine, in some instances on an embarrassingly long loan basis (abbreviations used in text are in parentheses): American Museum of Natural History (AMNH); Field Museum of Natural History (FM); Museum of Vertebrate Zoology (MVZ); Museum of Comparative Zoology (MCZ); Denver Museum (DM); British Museum (Natural History) (BMNH); Louisiana State University Museum of Zoology (LSU); Los Angeles County Museum of Natural History (LACM); Royal Ontario Museum of Zoology (ROM); Musée Royal d'Histoire Naturelle, Brussels (Brus.); and, of course, the U.S. National Museum of Natural History (USNM). E. R. Blake and L. L. Short read the manuscript.

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PROCEEDINGS
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TAXONOMIC IMPLICATIONS OF THE KARYOTYPES
OF *MOLOSSOPS* AND *CYNOMOPS* (MAMMALIA:
CHIROPTERA)

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Cabrera (1958:116) treated *Cynomops* Thomas, 1920, as a subgenus of *Molossops* Peters, 1865. Subsequently, most authors have either followed Cabrera (e.g., Goodwin and Greenhall, 1961; Jones and Dunnigan, 1965) or have not commented on subgeneric distinctions (Handley, 1966; Gardner et al., 1970); although, Husson (1962) used *Cynomops* at the generic level. Randolph L. Peterson, in a paper presented at the Third Annual North American Symposium on Bat Research (1972) and later (pers. comm.) also has favored generic status for both names. He would restrict *Molossops* to its type species, *M. temmincki* (Peters, 1865) and include all other currently recognized species under *Cynomops* (*Molossus cerastes* Thomas, 1901, type-species by original designation).

Heretofore, chromosomal studies on these bats (Linares and Kiblisky, 1969; Baker, 1970; Warner et al., 1974) contributed nothing toward elucidating the relationships between *Molossops* and *Cynomops*. Now, the karyotype of *Molossops temmincki* is available for comparison with those previously reported for *Molossops greenhalli* and *M. abrasus*. Also described herein is a chromosomal variant of *M. greenhalli* discovered during the course of investigations by this laboratory on the mammal fauna of the Mexican state of Nayarit.

Chromosomal material was prepared following the colchicine-hypotonic citrate sequence described by Patton (1967).

Definitions of fundamental number (FN) and terms describing chromosomal morphology were given by Patton (1967). The Colombian and Mexican specimens reported on here are deposited in the mammal collections of the National Museum of Natural History (USNM).

DESCRIPTION OF KARYOTYPES

Molossops temmincki griseiventer Sanborn.— $2n = 42$, FN = 56 (Fig. 1a). Autosomes: 1 pair of large and 5 pairs of medium-sized metacentrics and submetacentrics; 2 pairs of small subtelocentrics; and 12 pairs of medium-sized to small acrocentrics. Sex chromosomes: X, a medium-sized subtelocentric; Y, a small acrocentric.

Material examined: COLOMBIA; Intend. Meta, Villavicencio, Finca Buque (1 male, 1 female; USNM 507210–11).

Molossops greenhalli mexicanus Jones and Genoways.— $2n = 34$, FN = 60 (Fig. 1b). Autosomes: 2 pairs of large and 6 pairs of medium-sized metacentrics and submetacentrics; 3 pairs of large and 3 pairs of medium-sized subtelocentrics; and 2 pairs of small acrocentrics. Sex chromosomes: X, assumed to be a medium-sized subtelocentric; Y, not known since no males of this population have been analyzed. The Y of other populations is a small subtelocentric (Baker, 1970; Warner et al., 1974).

Material examined: MÉXICO; Nayarit, Río Chilte, 480 ft., 1.2 mi S (by road) El Casco (1 female; USNM 511544).

Molossops greenhalli greenhalli (Goodwin).— $2n = 34$, FN = 60 (Fig. 1c). Autosomes: a graded series of 11 pairs of large to medium-sized metacentrics and submetacentrics; 3 pairs of medium-sized subtelocentrics; and 2 pairs of small acrocentrics. Sex chromosomes: X, a medium-sized subtelocentric; Y, a small submetacentric. This karyotype was described by Baker (1970), for a Trinidadan male, and Warner et al. (1974) for Costa Rican specimens. Linares and Kiblicky (1969), reporting on a Venezuelan male, described the sex chromosomes as a medium-sized metacentric X and a small metacentric Y.

Molossops abrasus (Temminck).— $2n = 34$, FN = 60. The karyotype of a Peruvian female is the same as that of *M. greenhalli* from Trinidad and Costa Rica (Warner et al., 1974).

DISCUSSION

The karyotype of *Molossops temmincki* ($2n = 42$, FN = 56) differs markedly from that of *M. greenhalli* and *M. abrasus* ($2n = 34$, FN = 60). The differences support the recognition of *Molossops* and *Cynomops* at least at the subgeneric level. This range of karyotypic variation, while unusual in the chromosomally conservative Molossidae, is exceeded within the genus *Eumops* ($2n = 38$ to 48, FN = 56–64). *Eumops* and



FIG. 1. Representative karyotypes of *Molossops* and *Cynomops*. (a) *M. (Molossops) temmincki*; $2n = 42$, FN = 56; female; Villavicencio, Meta, Colombia; USNM 507210. (b) *M. (Cynomops) greenhalli mexicanus*; $2n = 34$, FN = 60; female; Río Chilte, Nayarit, México; USNM 511544. (c) *M. (Cynomops) greenhalli greenhalli*; $2n = 34$, FN = 60; female; Finca Lornessa, Santa Ana, San José, Costa Rica; Louisiana State University Museum of Zoology 13000.

Molossops (sensu lato) are also the only molossid genera known to have more than one diploid number (Warner et al., 1974). The karyotype of *Molossops temmincki* is closest to that of *Eumops auripendulus* ($2n = 42$, $FN = 60$) from which it differs in having a lower fundamental number (56), a subtelocentric X, and a small acrocentric Y. *Eumops auripendulus* has a metacentric X and a medium-sized subtelocentric Y. *Molossops temmincki* also has the same fundamental number as *E. underwoodi* and *E. perotis*. But, despite these and other chromosomal similarities, *Molossops* (sensu lato) and *Eumops* most certainly have independent evolutionary histories.

Although the karyotypic differences between *Molossops* and *Cynomops* are striking, we are left with the following question. Does recognition of *Molossops* and *Cynomops* at the generic level better reflect the true relationship between these taxa, or does it obscure their close phylogenetic affinity? Final resolution of this question clearly must await a detailed revision of the group.

The karyotype of *M. greenhalli mexicanus* differs from that of other populations of this species in the positions of the centromeres and the relative lengths of the autosomes (contrast b and c in Fig. 1). The two large metacentric and submetacentric pairs are equalled in size by two of the three pairs of large subtelocentrics. The latter are not present among the autosomes of other populations that have been analyzed. These differences are most likely the result of alterations of a karyotype, like that of Central and South American members of the species, through unequal translocations. Pericentric inversions and heterochromatin additions or deletions also may have contributed to the altered morphology of the autosomes.

The karyotype of the female from Nayarit is sufficiently distinct from that of the Costa Rican population to suggest the possibility of reproductive isolation (hybrid sterility) between their respective populations. Samples from these and intermediate populations should be compared to determine if additional evidence exists to support recognition of *mexicanus* at the species level.

Molossops greenhalli mexicanus, although previously unrecorded from Nayarit in the literature, was first discovered in that State by Terry Vaughan and Gary Bateman who collected two specimens at Los Limos and another at nearby La Peña. These three, all females, are deposited in the mammal collections of the Northern Arizona University Museum of Vertebrates (NAU 1412, 1414, and 1264). The species is known elsewhere in México from the states of Jalisco, Guerrero, and Oaxaca (Jones and Dunnigan, 1965; Jones and Genoways, 1967) at localities all within the Pacific coastal region of western México.

Field work in Colombia was conducted under the auspices of INDERENA and I am deeply appreciative of the assistance rendered by personnel of the División de Parques Nacionales y Vida Silvestre, in particular Drs. Jorge Hernández C. and Simón M. Franky V. Investigations in México were kindly facilitated by Lic. Mario Luis Cossio G.,

director of the Dirección General de La Fauna Silvestre, under whose auspices collecting permits were acquired.

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TAXONOMIC STATUS OF *SYNSYNELLA* HAY AND
BOPYRO PEARSE (ISOPODA: BOPYRIDAE)

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Two genera of Bopyridae, *Synsynella* Hay and *Bopyro* Pearse have had an interesting history. *Synsynella deformans* Hay (1917) was described from Onslow Bay, North Carolina, as a parasite of *Synalpheus longicarpus* (Herrick). Chopra (1923) described a species, that superficially resembled *S. deformans*, as *Bopyrella deformans indica*, thus synonymizing *Synsynella* Hay with *Bopyrella* Bonnier. However, Chopra's species has 5 pairs of biramous pleopods, whereas Hay's *Synsynella* has only 4 pairs, none of which is biramous. Nierstrasz and Brender à Brandis (1929) apparently accepted Chopra's erroneous conclusion that *Synsynella* Hay had 5 pairs of biramous pleopods, but because both the first and second peraeonites were fused with the cephalon in the adult female, and not just the first peraeonite as in *Bopyrella*, they reinstated *Synsynella*. Nierstrasz and Brender à Brandis (1929) also erected a closely related genus, *Prosynsynella*, and remarked that the adult female was indistinguishable from what they called *Synsynella deformans* Hay: "Diese Gattung (*Prosynsynella*) ist *Synsynella* nah verwandt. In der Tat sind die Weibchen nicht von einander zu trennen" (Nierstrasz and Brender à Brandis, 1929, p. 36). Monod (1933) illustrated a specimen which fits the characteristics of *Synsynella* as modified by Nierstrasz and Brender à Brandis, that is with all

peraeonites dorsally fused in the adult female. This he called *Synsynella deformans* Hay var. *indica* Chopra.

Bopyro was established by Pearse (1932) for *Bopyro choprae* from Tortugas, Florida, from *Synalpheus brooksi* Coutiere. The only other reports of *B. choprae* known to us are by Pearse (1950) from Onslow Bay, North Carolina, on *S. longicarpus* and *Synalpheus minus* (Say), and Pearse (1951) from Bimini on *S. brooksi*. In a recent study (Menzies and Kruczynski, in press) we concluded that *Bopyro* was a synonym of *Synsynella*, but because we lacked type-material, a definite union of these genera remained in doubt. We have now examined holotypes of *S. deformans* and *B. choprae* and herein confirm our union, and provide necessary corrections in the previous descriptions.

Synsynella Hay 1917

Synsynella Hay 1917:571-572.—Menzies and Kruczynski, in press.
Bopyro Pearse 1932:1-3.

Type-species: *Synsynella deformans* Hay 1917.

Type-locality: Onslow Bay, North Carolina, from branchial cavity of *Synalpheus longicarpus* (Herrick).

Emended diagnosis: Female (Fig. 1 A-C). Branchial parasite. Body slightly asymmetrical, tapering posteriorly. Cephalon quadrate with anterolateral processes, one sharper than other and recurved. Eyes present. Cephalon fused middorsally with peraeonites I and II. Peraeonites III-VII separated dorsally. Coxal plates on peraeonites I-IV, visible in dorsal view on peraeonites II-IV. Six pleonites indicated laterally, fused on mid-dorsum. Terminal pleonite bifid. Four pairs of uniramous pleopods. Marsupium open ventrally, with 5 pairs of oostigites. Uropods lacking.

Remarks: This diagnosis differs from Hay's generic diagnosis in the description of coxal plates and pleopods. Hay described the female as follows: "First four abdominal segments completely fused in middle region, but free at the sides; last two segments completely fused; other segments distinct. Pleopods usually rudimentary but with indications of being biramous." Hay also gave as a species characteristic "Epimeral plates present on the second, third and fourth segments on both sides of the body, but smaller on the short side." We found coxal plates on the first 4 peraeonites on both sides.

Hay did not designate an allotype, and illustrated in photographs 2 very different males. He described one as abnormal with only 3 pleonites. We feel that it is possible that Hay confused several species in his diagnosis. This supposition is supported by our examination of female

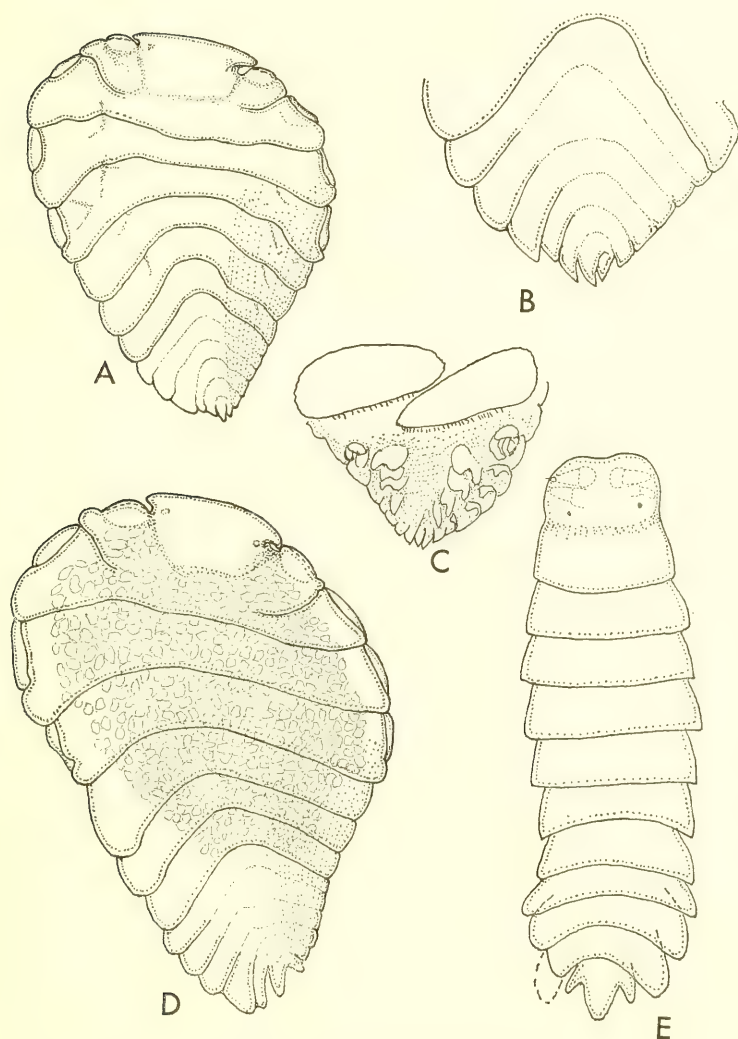


FIG. 1. A–C, *Synsynella deformans* holotype female, $l = 5.2$ mm, $w = 4.5$ mm: A, Whole animal, dorsal view; B, Pleon, ventral view; C, Pleon, dorsal view. D, *Bopyro choprae* holotype female, $l = 6.2$ mm, $w = 4.3$ mm, whole animal, dorsal view; E, *Bopyro choprae* allotype male, $l = 1.2$ mm, $w = 0.4$ mm, whole animal, dorsal view.

paratypes of *S. deformans*. Of the 3 paratypes examined, we found 2 with pleopods like those described for the holotype; however the shape of the pleon of these is different from the holotype in having the sixth pleonite being widely separated. The third specimen has 3 biramous pleopods and a fourth bilobed pleopod. Also, this latter specimen has the second peraeonite free, not fused with peraeonite I. Due to lack of information on the range of intraspecific variation in bopyrids in general, and due to the absence of males in the type-collection, we hesitate to describe these paratypes as new species or genera.

Hay's diagnosis of *Synsynella* as emended fits the holotype of *Bopyro choprae* (Fig. 1 D). In fact the holotype of *B. choprae* resembles the holotype of *S. deformans* more closely than do female paratypes of *S. deformans*. Thus, we consider *Bopyro choprae* a synonym of *Synsynella deformans*.

Previous distinctions between *Bopyro* and *Synsynella* were based on errors in Pearse's original illustration and interpretation. There is no need to cite each error, but the holotype clearly has the cephalon fused with the first 2 peraeonites, coxal plates on peraeonites I-IV, and dorsally fused pleonites. Examination of 34 female topotypes demonstrated variation among several characteristics used in distinguishing bopyrids. The shape of the terminal pleonite varied from bluntly pointed to sharply pointed (Fig. 2 A-D). The last 2 pleonites were missing on one specimen removed from a host (Fig. 2 E). There was also variation in the length of the fifth pleonite on the long side of the body and in the depth of lateral indications of pleonites of the short side of the body (Fig. 2). All specimens had 4 uniramous pleopods. Pleopod 4 was conical in all, but the first 3 pleopods were either bilobed or simple unilobed quadrate appendages. There was no apparent association between body size and lobing of the anterior pleopods. Thus, this characteristic mentioned by both Hay and Pearse is probably altered in fixation. However, it is important to note that the number of pleopods did not vary and that biramous pleopods were not found among this series of females.

The size of topotype females ranged from 1.5-3.8 mm length ($\bar{M} = 2.5$) and 0.8-2.8 mm width ($\bar{M} = 1.7$). Approximately equal numbers were removed from the right (56%) and left (44%) branchial chambers of host shrimps; one shrimp had both branchial chambers infected, and one parasitized shrimp was ovigerous. All except 2 specimens were observed with the posterior end situated toward the head of the host, and 8 females had males attached to the ventral surface of the pleon.

The allotype of *B. choprae* (Fig. 1 E) had the cephalon fused dorsally with peraeonite I and 4 free pleonites, the last being trilobed. Pearse, like Hay, may have had more than one species at his disposal when he described *B. choprae* as is suggested by the different male pleons he illustrated. Our examination of the 8 male topotypes and a male collected by Markham from the type-locality demonstrated little morphological variation of the pleonites or other characteristics. The

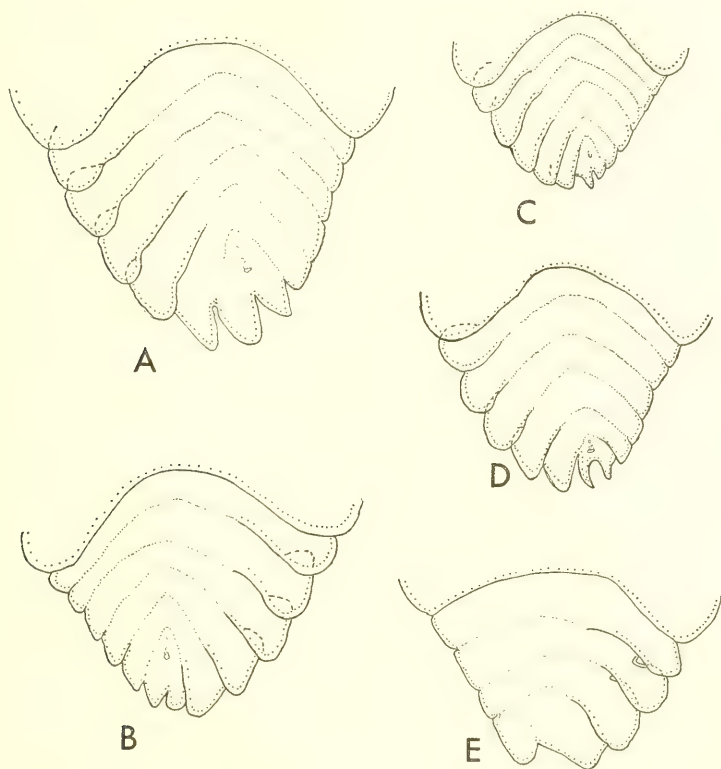


FIG. 2. A-E, Variation in pleon of 5 topotype females of *Bopyro choprae*.

only variation observed was in the shape of the central lobe of the last pleonite which varied from pointed to bluntly pointed. Males ranged in size from 0.5–0.9 mm length ($\bar{M} = 0.8$) and 0.1–0.3 mm width ($\bar{M} = 0.2$).

Material examined: *Synsynella deformans* Hay, holotype female, USNM 48371. *Synsynella deformans* Hay, paratype females, USNM 48372; paratype 1 may not be *Synsynella*-peraeonite II distinct dorsally, pleopods 1–3 biramous (examined by Bourdon, 1972); paratypes 2 and 3 with pleon more rounded distally than holotype, and last pleonite widely bifid—may be different species. *Bopyro choprae* Pearse, holotype female and allotype male, USNM 64488. *Bopyro choprae* Pearse, 34 females, 8 male topotypes, USNM 117110. *Bopyro choprae* Pearse, J. C. Markham ident., female and attached male, USNM 311208; the terminal

pleonite resembles that of holotypes of both *S. deformans* and *B. choprae*; the male is identical with the allotype *B. choprae*.

DISCUSSION

The taxonomy of the Bopyridae is quite confused. The subfamily to which *Synsynella* belongs, the Bopyrinae, is, as Nierstrasz and Brender à Brandis indicated in 1929, in need of major revision. Perhaps the main reason for confusion is the lack of any study of variability of characters within species. We examined 34 additional specimens of *B. choprae* and have discussed the characters that were variable. Dorsal demarkation of peraeonites and pleonites may be obscured at times, depending on the position of the parasite within the branchial cavity of the host. We believe that the type of articulation between the cephalon and peraeonites I and II, the number of coxal plates, and the number of pleopods and their configuration are taxonomic characters of generic importance. Also, the characteristics of males likely to show little variation are articulation of cephalon and peraeonite I, number of antennal articles, number of pleonites and pleopods, and shape of the pleon.

The characteristics which caused confusion for both Chopra (1923) and Nierstrasz and Brender à Brandis (1929) was the determination of the number and branching of pleopods. First, unlike Chopra's species, *S. deformans* has only 4 pairs of pleopods, none of which is biramous but may be bilobed in preserved specimens. Thus Chopra's "subspecies" is hardly a subspecies of *deformans* and may or may not belong to *Bopyrella*.

A serious problem in the examination of Bopyrinae is determining dorsal fusions of peraeonites and pleonites. Because of the significance of these fusions, their presence or absence must be carefully noted. We have found it very useful to stain whole female specimens with hematoxylin. In this way articulations are determined by clear, continuous dorsal demarkations. The fused segments may or may not show in reflected light as shallow, linear depressions, lacking a discrete border. Obviously, investigators will differ in their interpretation of a shallow line separating somites as a true separation, and because of this most previous descriptions of Bopyrinae should be examined with the possibility that fusions may or may not exist.

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A NEW SPECIES OF *TRAVISIA* (POLYCHAETA,
OPHELIIDAE) FROM TAMPA BAY, FLORIDA

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In a number of ecological studies dealing with Tampa Bay, Florida (Taylor, 1971; Bloom *et al.*, 1972; Simon and Dauer, 1972; Dauer, 1974; Dauer and Simon, 1975, 1976), some polychaetes, identified as *Travisia* sp., were consistently collected in large numbers. Closer examination of the specimens and the literature indicated that they belonged to the new species described herein. The purpose of the present paper is to describe this species.

***Travisia hobsonae*, new species**
Figure 1, a-g

Travisia sp. Taylor, 1971:575-576, fig. 12a.—Bloom, Simon and Hunter, 1972:47.—Simon and Dauer, 1972:232.—Dauer, 1974:66.—Dauer and Simon, 1975:365-367; 1976:107-110.

Material examined: WEST COAST OF FLORIDA: Stump Pass, 21 May 1960, R. T. Paine, 2 specimens (USNM 53265). Off Picnic Island, midway between Weedon Island and Port Tampa, and off Sunset Park-Bel Mar on Interbay Peninsula, Tampa Bay, 29 January 1959, M. L. Jones, 21 specimens (USNM 53266-53270). Tampa Bay, 1963, J. L. Taylor, 12 specimens (USNM 45653). Courtney Campbell Causeway (Middle), 2/6 March and 24 April 1964, J. L. Simon, 123 specimens (USNM 53261-3). Courtney Campbell Causeway (Middle), 17 May 1975, S. L. Santos, holotype (USNM 53476) and 3 paratypes (USNM 53477), 3 paratypes (Allan Hancock Foundation POLY 1142) and 2 paratypes (Invertebrate Zoology Museum, University of South Florida).

Description: Length of holotype 14 mm, width 2 mm, setigerous segments 31. Lengths of 167 specimens ranged from 6 to 27 mm, widths from 0.7 to 4 mm, setigerous segments 30-31 (sometimes fewer in

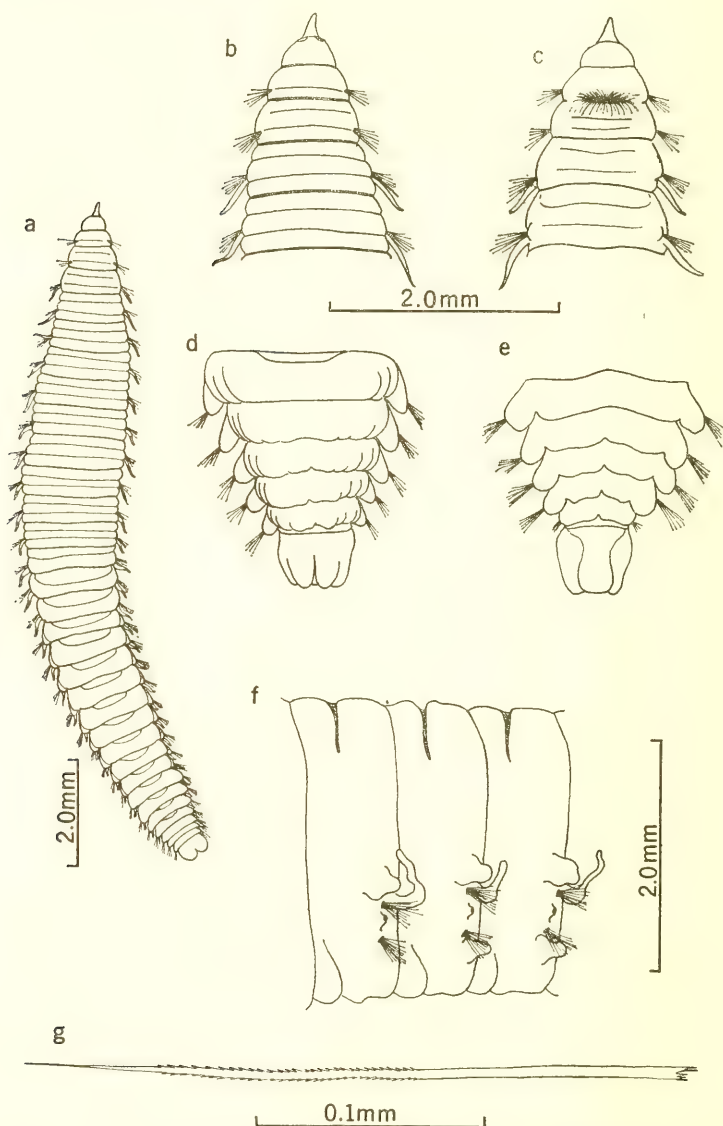


FIG. 1. *Travia hobsonae* n. spec. a, Holotype, entire animal, dorsal view; b, Holotype, anterior, dorsal view; c, Holotype, anterior, ventral view; d, Paratype, posterior, dorsal view; e, Paratype, posterior, ventral view; f, Holotype, lateral view of setigers 16, 17 and 18 (anterior to left); g, Holotype, hispid seta from 10th notopodium.

juveniles). Branchiae 28–29 pairs (fewer in juveniles). Smallest specimens, possessing 31 setigers and 29 pairs of branchiae, measured 9 mm long by 1.6 mm wide.

Body subfusiform-fusiform, widest at about setigers 12–13, completely covered with small rounded pustulae (Fig. 1a). Slightly developed midventral groove present from about setiger 14 to posterior end, apparently associated with muscular ridges; groove indistinct in living specimens.

Prostomium small, conical, with 2 nuchal pits on dorsal base (Fig. 1b). First segment achaetous. Segment 2 (setiger 1) biannulate dorsally but not ventrally. Noto- and neurosetae inserted on anterior parts of posterior annuli (Fig. 1b). Ventral mouth enclosed by posterior border of setiger 1 and anterior border of setiger 2 (Fig. 1c). Eversible saccular proboscis, well developed, highly folded and smooth. Setigers 2–12 triannulate, with annuli discontinuous laterally. Noto- and neurosetae inserted on anterior parts of posterior annuli. Setigers 13–26 or 27 biannulate, also discontinuous laterally with setae inserted on posterior annuli (Fig. 1f). Setigers 27 or 28 to end entire. Noto- and neuropodial tufts of setae present on all setigers; setae simple capillary and hispid (Fig. 1g).

Notopodial lappets beginning on setiger 1, small to setiger 13, large thereafter to end; neuropodial lappets inconspicuous up to setigers 16, 17 or 18, then becoming large and continuing to end (Fig. 1f). Crenulations or lacinations of the posterior parapodia sometimes present; on larger specimens, entire lateral and dorsal posterior margins of posterior segments crenulated (Fig. 1d).

Nephridiopores on setigers 3–14, slightly anterior and ventral to neuropodial setal tuft. Interramal sensory pits between notopodial and neuropodial setal tufts on all setigers (Fig. 1f).

Branchiae 28–29 pairs, beginning on setiger 3 and continuing to end, simple, cirriform, capable of being withdrawn into body (Fig. 1a).

Pygidium provided with 5 large rounded lobes surrounding terminal anus (Fig. 1e); sometimes 5 major and up to 4 minor lobes in larger specimens.

Color: Living animals pinkish, grayish in alcohol.

Biology: *T. hobsonae* produces a fetid odor when handled and secretes copious amounts of mucus to which sand grains readily adhere, giving the appearance of a more or less definite tube. It occurs in greatest densities in clean medium to fine sand (mean diameter = 0.125 mm).

Type-locality: Tampa Bay, Florida, U.S.A.

Distribution: West Coast of Florida in Tampa Bay and Stump Pass.

Etymology: The species is named in honor of the late Mrs. Katherine D. Hobson, a distinguished polychaete taxonomist and a good friend.

Remarks: *T. hobsonae* resembles *T. fusiformis* Kudenov more closely than any other member of the genus. Both species have a fusiform body, slight midventral groove, sensory pits present on all setigers and

TABLE 1. Differences between *Travisia fusiformis* Kudenov and *Travisia hobsonae* new species.

	<i>T. fusiformis</i> Kudenov	<i>T. hobsonae</i> new species
Number of setigerous segments	34-35	30-31
Branchiae	Begin on setiger 2, to end of body	Begin on setiger 3, to end of body
Distribution of pustulae on body	On entire body except distal half of prostomium	On entire body including prostomium
Posterior lateral crenulations	Absent	Present or absent
Parapodial lappets; notopodial	Conspicuous throughout	Small on setigers 1-13, large from setiger 14 to end of body
neuropodial	Small papillae on setigers 2-16, well-developed from setiger 17 to end of body	Inconspicuous on setigers 1 through 15, 16 or 17; well-developed on setigers 16, 17 or 18 to end of body

branchiae and setae on all posterior segments. The main differences between the 2 species are summarized in Table 1.

The relative development of the midventral groove in *T. hobsonae* appears to be related to the preparation of the specimens. Those that are incompletely narcotized before fixation show a pronounced groove, whereas the specimens that are properly narcotized exhibit a very slight midventral groove.

Kudenov (1975) feels that the presence of a midventral groove in *T. fusiformis* Kudenov could qualify for the erection of a new genus, with *T. fusiformis* as the type-species. His reasoning is based in part on the definition of *Travisia* Johnston, which includes opheliid polychaetes with grub-like bodies that lack midventral grooves. Kudenov (pers. comm.) also expresses the opinion that the new genus should be defined to include *Travisia*-like opheliids with lateral segmental swellings and fusiform-subfusiform bodies in addition to the midventral grooves.

I have examined some specimens identified as *Travisia forbesii* Johnston (USNM 323), the type-species of the genus, and found them to possess slight midventral grooves, segmentally arranged lateral

swellings and fusiform-subfusiform bodies. I feel that any further discussion on the erection of a new genus based on the above-mentioned characters should await the examination of the holotype of *T. forbesii* Johnston.

ACKNOWLEDGEMENTS

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PROCEEDINGS
OF THE
BIOLOGICAL SOCIETY OF WASHINGTONA NEW GENUS OF PRIMITIVE MARINE HADZIID
(AMPHIPODA) FROM BIMINI AND PUERTO RICO

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A new genus of marine hadziid bearing eyes and well developed male gnathopod 2 typical of marine gammarid amphipods (Crustacea) is described from shallow marine waters of Bimini and Puerto Rico. The family Hadziidae, established by S. Karaman (1943) and later synonymized with Gammaridae by Stock and Nijssen (1965), is resurrected, newly diagnosed and restricted in content.

Hadziids are primarily Tethyan in distribution and were originally discovered in caves of Yugoslavia by S. Karaman (1932). Most of the taxa are subterranean, having been found in ground waters and caves of the Mediterranean, in northern Mexico, or on islands of the Indian Ocean, and Caribbean Sea. Only three species, including that described herein, occur in fully marine habitats. The first to be discovered was *Liagoceradocus pusillus* J. L. Barnard, 1965, from a Micronesian atoll. Barnard did not recognize the "freshwater" affinity of his blind species and erected a new genus, *Liagoceradocus*, now recognized as a synonym of *Hadzia*.

A second IndoPacific species was established by Barnard (in press). That species lives in anchialine environments (Holthuis, 1973, anchialine, "near the sea") i.e., in lava ponds of Hawaii. Lava ponds are pools of brackish water near the sea in lava fields, the ponded water being interconnected by percolation to underground porous aquifers which themselves are influenced by ingressing seawater. A third marine hadziid,

Dulzura sal, was described by Barnard (1969) from the marine intertidal of southern California, but again was not recognized as a taxon having affinity with *Hadzia*. That monotypic genus is also blind but lives among the roots or basal stems of the seagrass, *Phyllospadix* sp., or on substrates under rocks.

Eriopisa schoenerae Fox, 1973, is removed to our new genus as the type-species of *Protohadzia*. It is a marine species originally found in Bimini Lagoon, Bahama Islands, and here reported in fully adult male condition from Puerto Rico.

Hadzia curasavica (Stephensen, 1933) occurs in marine salines of Curaçao but these are not anchialine (Stock, in litt.). All other species of the family occur in groundwater or caves not associated with the sea. We consider only *Protohadzia schoenerae*, *Dulzura sal*, and *Hadzia pusilla* to be of fully marine occurrence.

TERMS

The following terms are used to describe stages of uropod 3:
Dispariramus, outer and inner rami dissimilar;

Aequiramus, outer and inner rami similar in length, shape and patterns of armament;

Magniramus, both rami extending equally (rami can differ in spination and therefore be either *dispariramus* or *aequiramus*);

Parviramus, inner ramus reduced to a scale lacking all but terminal armaments (uropod 3 therefore *dispariramus*);

Viriramus, inner ramus not fully elongate, often of *parviramus* form but bearing armaments other than terminal (uropod 3 therefore *dispariramus*).

Presence of a conspicuous article 2 on the outer ramus results in a classification of *dispariramus*; such uropod 3 can be *magniramus*, *viriramus* or *parviramus*; an *aequiramus* uropod 3 is always *magniramus* but a *magniramus* uropod 3 is not always *aequiramus*.

Family HADZIIDAE (sensu stricto), revived

S. Karaman, 1943:206.

New diagnosis: Coxal gills present on pereonites 2-6. Inner plates of maxillae densely setose medially, maxilla 2 with oblique facial row

on inner plate. Gnathopod 1 of melitid form, small, wrist elongate, hand subrectangular, palm transverse or nearly so, gnathopod 2 of female enfeebled but larger than gnathopod 1, wrist slightly to greatly elongate, diamond shaped, hand elongate, slender, palm indistinct from posterior margin of hand, latter bearing groups of sparse, stiff, apically curved setae; gnathopod 2 of male various, either similar to female or of enlarged version or weakly similar to ceradocid gnathopod 2 but wrist diamond shaped, not apically invaginated to fit hand. Uropod 1 with stout basofacial spine(s) on peduncle. Telson cleft. Segments of urosome free, naked or bearing scattered spines never organized into contiguous groups, usually one dorsolateral spine on weak tooth on each side of urosomite 2. Uropod 3 dispariramus.

Description: Accessory flagellum 1–4 articulate. Antenna 1 longer than antenna 2, nongeniculate. Lateral cephalic cheeks unnotched. Male gnathopod 2 usually with medial pubescence on wrist.

Type-genus: *Hadzia* Karaman, 1932

Composition: *Dulzura* J. L. Barnard, 1969; and *Protohadzia*, new genus. The Hadziidae in strictest sense, comprising *Hadzia*, *Protohadzia*, and *Dulzura*, differ from the restricted Melitidae as outlined by Barnard (1976) in the special form of female gnathopod 2, on which the palm is obsolescent and the sparse groups of stiff and bent posterior setae of the hand extend into the margin against which the dactyl closes.

No melitid has these setae extended into that position, though *Eriopisa longiramus* Stock and Nijssen (1965) and *Psammoniphargus* Ruffo have those posterior setae. In the latter 2 taxa, however, the palm of female gnathopod 2 is distinct and well defined.

The weckeliid genera as listed by Barnard (1976) do not necessarily have those setae extended into the palm of female gnathopod 2. That situation plus the aequiramus uropod 3 suggest that weckeliids and hadziids are distinct at family level and have different origins. Hadziids are clearly of melitid origins from the vicinity of such ancestral types as *Eriopisa longiramus* (requiring a distinct genus) whereas weckeliids appear to have origins in the ceradocid group, perhaps near *Paraweckelia*.

Members of *Eriopisa* and *Hadzia* (and allies) have been confused in the past, mainly by J. L. Barnard (1970) who described 2 species of *Eriopisa*, which now are shown to be in the Hadziidae. Through the advice and precedents of the junior author, Fox (1973) assigned his species *schoenerae* to *Eriopisa* but the new definitions of the families and genera presented by Barnard (1976) demonstrate the proper allocations of the several species. The species of *Eriopisa* are restricted to the following: *australiensis* (Chilton), *chilensis* (Chilton), *epistomata* Griffiths, *garthi* J. L. Barnard, *peresi* Ledoyer, *philippensis* (Chilton) and *seurati* Gauthier. *Eriopisa longiramus* Stock and Nijssen and *E. caeca* (S. Karaman) should be assigned to the revived genus *Psammogammarus* S. Karaman based on the apparent loss of sexual dimorphism in gnathopod 2 and the evenly but minutely spinose palm of gnathopod

2. *Eriopisa* (?) *hamakua* J. L. Barnard is transferred to *Dulzura* and *E. laakona* J. L. Barnard is transferred to *Hadzia*.

The following genera were formerly aligned with hadziids but are placed in or near the Melitidae because of their non-hadziid female gnathopod 2 and/or the presence of fleshy inner lobes on the lower lip: *Paraheckelia*, *Paraniphargus*, *Psammoniphargus*, and *Eriopisa*. *Eriopisella*, *Netamelita*, *Microniphargus* and *Indoniphargus*, as a family group, are characterized by the neotenic ("heterochronous") gnathopod 2.

Metacrangonyx is an obvious apomorph of the Hadziidae but it is removed from the Hadziidae because of the extreme reduction in uropod 3 and the fusion of the telsonic lobes. *Dulzura* may be an aberrant hadziid but it also could be derived from melitids and may have to be removed to a satellite position. *Dulzura* lacks inner lobes on the lower lip, but male gnathopod 2 is not hadziid because it has a setose palm.

The Hadziidae therefore comprise 3 genera with primarily Tethyan distributions. *Hadzia* is the most widespread genus, containing one marine species in a Micronesian atoll, 2 species in anchialine and marine environments of Hawaii, 4 species in underground waters or caves of Caribbean islands, and 4 species in European caves and groundwater in Portugal, Italy and Yugoslavia. *Protohadzia* is represented by one species from *Thalassia* beds and lagoons in shallow marine waters of Bimini and Puerto Rico. As a satellite, *Dulzura* is known by 2 species from the marine intertidal of California and Hawaii.

Dulzura hamakua (J. L. Barnard), new combination

Eriopisa (?) *hamakua* J. L. Barnard, 1970:138-140, figs. 83, 84

Remarks: *Eriopisa* (?) *hamakua* from Hawaii is transferred to *Dulzura*. It differs from the type-species, *D. sal* J. L. Barnard, in the nasi-form shape and sharp posterior point on epimeron 3.

Hadzia (?) *laakona* (J. L. Barnard), new combination

Eriopisa laakona J. L. Barnard, 1970:140-143, figs. 85, 86.

Remarks: *Eriopisa laakona* from Hawaii is transferred to *Hadzia* with a questionmark to denote the possibility that it represents a new genus of the Hadziidae characterized by shortened telson. In any event it is no longer referable to *Eriopisa*.

KEY TO THE HADZIID AND WECKELIID GENERA

1. Uropod 3 dispariramus, outer ramus 2-articulate 2
 Uropod 3 aequiramus, outer ramus 1-articulate 4
2. Eyes present, male gnathopod 2 palm with apical protrusion
 *Protohadzia*
 Eyes absent, male gnathopod 2 lacking apical protrusion 3
3. Male gnathopod 2 with densely setose palm *Dulzura*

- Palm of male gnathopod 2 not densely setose, with small spines
and occasional seta *Hadzia*
4. Mandibular palp 3-articulate *Alloweckelia*
- Mandibular palp 0-1-articulate 5
5. Male gnathopod 2 neotenic, small, palm short and highly distal
..... *Mexiweckelia particeps*
- Male gnathopod 2 enlarged, palm elongate 6
6. Mandibular palp 1-articulate, accessory flagellum 4-articulate
..... *Weckelia*
- Mandibular palp absent, accessory flagellum 0-1-articulate
..... *Mexiweckelia*

Protohadzia, new genus

Diagnosis: Eyes present but lacking ommatidia; accessory flagellum 2-articulate; mandibular palp 3-articulate; male gnathopod 1 with 4 rows of long facial setae on article 5; male gnathopod 2 extremely enlarged, palm poorly setose, with apical spinose projection, dactyl crenulate on inner margin but lacking teeth or spines; uropod 1 lacking special apicomedial spine but apicolateral margin with special spine; urosome naked dorsally; uropod 3 with 2 articles on outer ramus; uropod 2 with apicomedial comb.

Type-species: *Eriopisa schoenerae* Fox, 1973. Genus monotypic. Gender feminine.

Relationship: The key to genera of haziids and weckeliids is arranged more or less in a phyletic order with progress from primitive to advanced genera, and progress from marine to freshwater habitation. *Protohadzia* appear to be very primitive in the presence of eyes, the highly enlarged male gnathopod 2 with differentiated palm similar to other marine gammarids and in the normalcy of other characters such as fully developed mandibular palp and article 2 on the outer ramus of uropod 3, in the basalwards position of the basofacial spine on uropod 1, in the absence of inner spines on the dactyl of gnathopod 2 and in the absence of dorsal spination on the urosome.

Protohadzia is specialized, however, in the grossly setose outer face of article 5 on male gnathopod 1 and in the extremely shortened inner ramus of uropod 3 and therefore *Protohadzia* is not the perfect ancestral model to the other genera.

Protohadzia belongs to the hadziid group of the Gammaridae (sensu lato) in which female gnathopod 2 is enfeebled. The wrist is elongate, the hand is thin, the palm is either very short and strongly overlapped by the dactyl or merges completely with the posterior margin of the hand, and the posterior part of the hand is armed with stiff apically curved setae. In hadziids male gnathopod 2 is often very similar or identical to female gnathopod 2 or is enlarged. In the enlarged form the palm and posterior margin of the hand merge almost completely even if the apex is sculptured. Inner lobes of the lower lip are absent.

Uropod 3 of *Protohadzia* is dispariramus, the outer ramus 2-articulate and the inner ramus uniarticulate. Uropod 3 is also parviramus, the inner ramus being reduced to the form of a scale and lacking medial setae. In *Hadzia*, uropod 3 varies between the almost fully magniramus form to the almost fully parviramus form, but because it does not quite reach either extreme, it is best categorized as variramus. *Protohadzia* differs from *Hadzia* in the closely proximal placement of the basofacial spine on uropod 1 and in the well developed, almost ceradocid-like male gnathopod 2. Uropod 3 of weckeliids such as *Weckelia*, *Mexiweckelia* (sensu lato) and *Alloweckelia* is almost aequiramus and is generally magniramus. This raises the possibility that they may have different ancestors from *Hadzia* and *Protohadzia*, possibly in the ceradocids, near *Para-weckelia*.

An ancestor to *Protohadzia* would be visualized as having the magniramus uropod 3 with elongate inner ramus similar to many species of *Hadzia*, especially those of Europe. Several of the Caribbean species of *Hadzia* have a somewhat shortened inner ramus and most species of *Hadzia* have developed medial spines on the telsonic lobes.

In many ways, *Eriopisa longiramus* Stock and Nijssen, 1965, fits the ancestral model. It appears to be the next closest morphotype to *Hadzia* and *Protohadzia*. Uropod 3 is variramus and dispariramus but the inner lobes of the lower lip are large and fleshy and female gnathopod 2 has a distinct palm, so that it must be assigned to the melitid genera. In that group, uropod 3 of *E. longiramus* is unique because other melitids have a fully parviramus uropod 3. If such genera as *Pontoniphargus* in the niphargid group are to be retained because of variramus uropod 3 then *Eriopisa longiramus* probably should be assigned to a new genus but for the moment could be allocated to *Psammogammarus* S. Karaman. *Eriopisa longiramus* has a much better developed female gnathopod 2 than the hadziids, the palm being distinct and defined. However, the wrist is elongate as in hadziids and the bent posterior setae on the hand are weakly developed. *Eriopisa longiramus* would form a good plesiomorph of hadziids, just as it does of *Eriopisa*, but it is not generally ancestral to melitids because of adaptations such as reduced coxae.

The geographically contiguous *Alloweckelia*, known from a cave in Puerto Rico, shares with *Protohadzia* the strongly basal spine on uropod 1 but otherwise differs in the fusion of article 2 on the outer ramus of uropod 3 to article 1 and in the development of dorsal spination on the urosome, the loss of structure on male gnathopod 2, and the slight development of ornaments on the inner edge of the dactyl. The latter character suggests that *Alloweckelia* might have a more direct relationship to *Protohadzia* than to *Hadzia* in which the dactylar ornaments have developed fully into spines, but *Alloweckelia* bears an elongate inner ramus on uropod 3 and cannot be a direct descendent of *P. schoenerae*.

Alloweckelia shows the stepwise intergradation between *Protohadzia* and the various taxa of the *Mexiweckelia* group, including *Weckelia* and

M. particeps, in the smallness of the mandibular palp and the loss of articulation apically on the outer ramus of uropod 3. In the *Mexiweckelia* group the outer ramus bears a long middle spine resembling an article but bearing an apical trigger and an apparent neural canal typical of spines (specimens of all species of the group except *M. texensis* re-examined in Smithsonian collections). The *Alloweckelia* and *Mexiweckelia* groups have lost the medial comb on the peduncle of uropod 2 typical of *Protohadzia*, *Hadzia* and *Dulzura*.

Paraweckelia has been placed by earlier students in the hadziid group but gnathopod 2 of the female is fully melitid in form. *Paraweckelia* is so close to *Ceradocus* that it can scarcely be distinguished. It has the normally midlateral setules shifted towards the apex of the telson. *Dulzura* has the fully hadziid form of gnathopod 2 but male gnathopod 2 is somewhat enlarged and the palm is densely setose, unlike *Hadzia* and *Protohadzia*. Uropod 3 is dispariramus and parviramus so that *Dulzura* would otherwise fit into the very narrowest hadziid group. It also lacks inner lobes on the lower lip like *Hadzia*, but in contrast to the *Weckelia* group where faint inner lobes persist. In melitids the plesiomorphic lower lip has fully fleshy inner lobes but these often are reduced, even in *Melita*, almost to the level seen in *Weckelia*. Hadziids may have a melitid ancestry as marked by the dispariramus uropod 3 and the weckeliids may have a ceradocid ancestry because of the aequiramus uropod 3 but both groups have many similarities in female gnathopod 2, although the development of an enfeebled gnathopod 2 could be a case of convergence. The same may be said of the mittenform gnathopods in the several genera of eriopisellids and in the salentinellids, where several ancestral morphotypes can be proposed.

Protohadzia schoenerae (Fox), new combination

Figures 1-5

Eriopisa schoenerae Fox, 1973:153-159, figs. 5-8.

Description of male: Ocular lobe of head distinct, marked below by weak excavation, anteroventral corner of head subquadrate, eyes present, composed of deep purple pigment granules in irregular blobs, occasionally split apart into several subdivisions or coalesced and vacuolate, ommatidia not visible. Antenna 1 elongate, article 1 with small apico-ventral spine, article 2 about 0.95 times as long as article 1, article 3 about 0.35 times as long as article 1, accessory flagellum with 2 articles, second article minute, primary flagellum with 21-23 articles, about 1.5 times as long as peduncle; article 5 of antenna 2 about 1.1 times as long as article 4, flagellum with 13 articles, about 1.55 times as long as article 4. Prebuccal parts almost flat anteriorly, upper lip pyriform, distinct from epistome. Right lacinia mobilis weakly bifid, poorly gaping, each branch densely denticulate, right rakers 4, raker number 2 largest and apically brushy, left rakers 4, all thin and similar to each

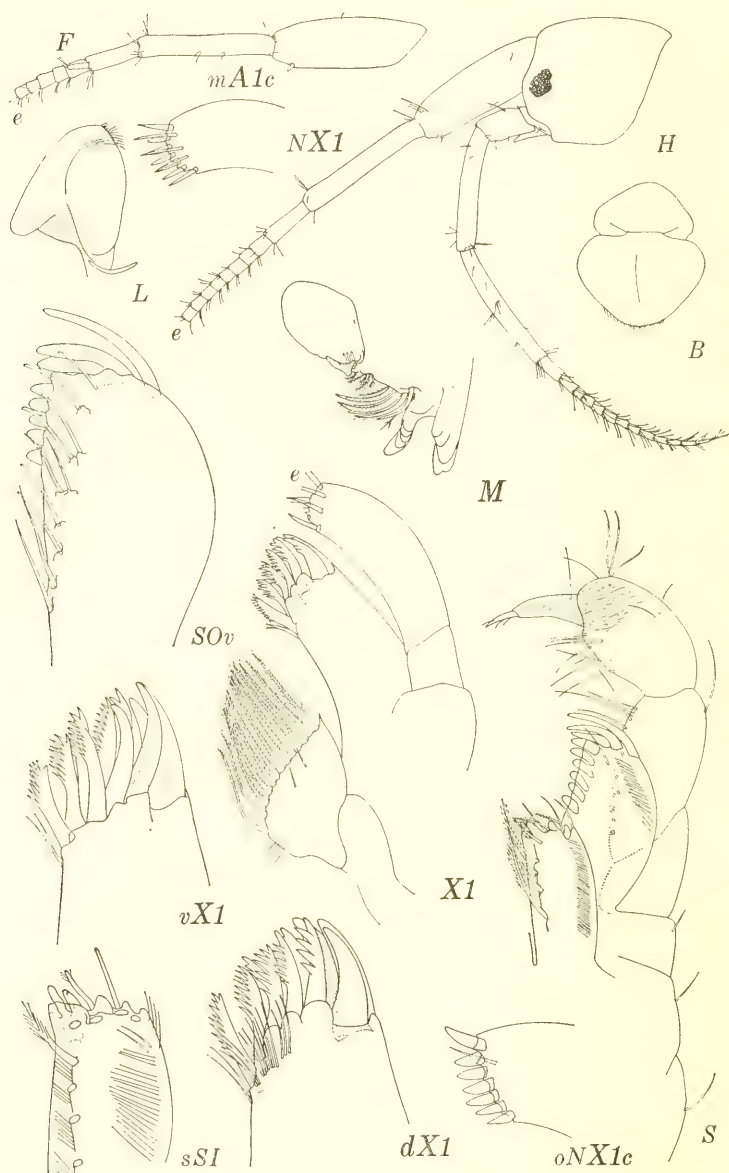


FIG. 1. *Protodhadzia schoenerae* (Fox), male "a" 5.16 mm; c = female "c" 4.42 mm. A, Antenna; B, Prebuccal, anterior; C, Coxa; D, Dactyl; E, Epimeron; F, Accessory flagellum; G, Gnathopod; H, Head; I, Inner plate or ramus; J, Pleopod; L, Lower lip; M, Mandible; N, Palp;

other, left rakers each pair with intercalated plusetule, left molar with flake, right molar with sinus at position of flake base seen on left molar, palp article 1 weakly elongate, article 2 with 2 inner setae, article 3 about 1.25 times as long as article 2, thin, falciform, closely lined with medial spines along inner curve from mark 25 to apex. Lower lip lacking inner lobes. Inner plate of maxilla 1 densely setose medially, with sharp apical cusp, outer plate with 10 spines, oral surface with extended lobules on 3 spines, medial apex with 2 setules, right and left palps distinctive, right palp thin, bearing 6–7 thin apical spines and 1–3 submarginal facial setae, left palp broad, apex with 7 thick spines and one submarginal facial seta; inner plate of maxilla 2 slightly broader than outer plate, with medial setae and oblique facial row of setae. Inner plate of maxilliped subrectangular, significantly smaller than outer plate, article 1 of palp lacking apicolateral seta, apical nail of dactyl stout. Coxae 1–3 subquadrate, with weakly concave posterior margins, coxa 4 somewhat shorter, naked posteriorly. Article 5 of gnathopod 1 elongate, article 6 about 0.65 times as long as article 5, palm almost transverse, article 6 rectangular, article 4 with medial fuzz, article 5 with 4 oblique faciolateral rows of elongate setae, no medial fuzz, dactyl with several tube-setae (apices flared and circular); articles 3–5 of gnathopod 2 short, article 5 with posterodistal protrusion medially, article 5 with rounded-flat and setose posterior margin, posteromedial surface fuzzy, article 6 greatly elongate, about 3.3 times as long as article 5, palm and posterior margin confluent and sinuate, proximal part densely setose, distal part weakly setose and spinose, extended apically into adz-shaped false palm bearing spines and setae, postero-medial margin with weak callus for apex of deeply curved dactyl, latter situated at mark 55 on posterior margin, inner margin of dactyl weakly crenulate, lateral face of article 6 mostly naked, medial face with about 6 anterior groups of setae. No pereopodal dactyl with accessory outer distal setae but pereopods 5–7 with additional inner flagellar scale at base of main setule; coxa 5 small; article 2 of pereopods 5–7 narrow, subrectangular, each with weak posteroventral lobe, article 2 of pereopod 5 tapering proximally, article 5 of pereopod 6 with special postero-medial comb of long spines. Epimera 1–3 with small posteroventral tooth, epimera 1–2 with facial ridge, epimeron 1 naked, epimeron 2 with one ventrofacial spine, epimeron 3 with 5 ventral spines and occasionally with submarginal facial spine. Basofacial spine on peduncle of uropod 1 short and strongly shifted proximally (from position normal to other

←

O, Outer plate or ramus; P, Pereopod; R, Uropod; S, Maxilliped; T, Telson; U, Molar; V, Gill; W, Pleon; X, Maxilla; Y, Lacinia mobilis; d, Dorsal; e, Removed or missing; m, Medial; n, Peduncle; o, Opposite; s, Setae removed; u, Right; v, Ventral.

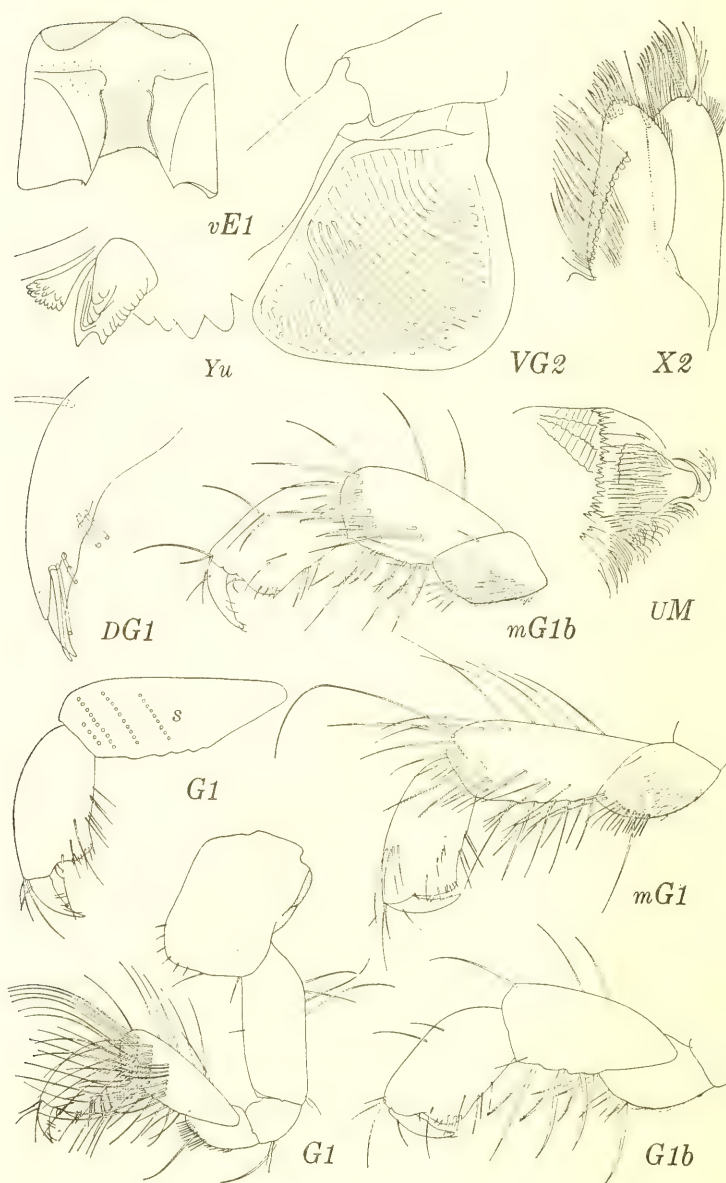


FIG. 2. *Protohadzia schoenerae* (Fox), male "a" 5.16 mm; b = female "b" 3.37 mm. See fig. 1 for symbols.

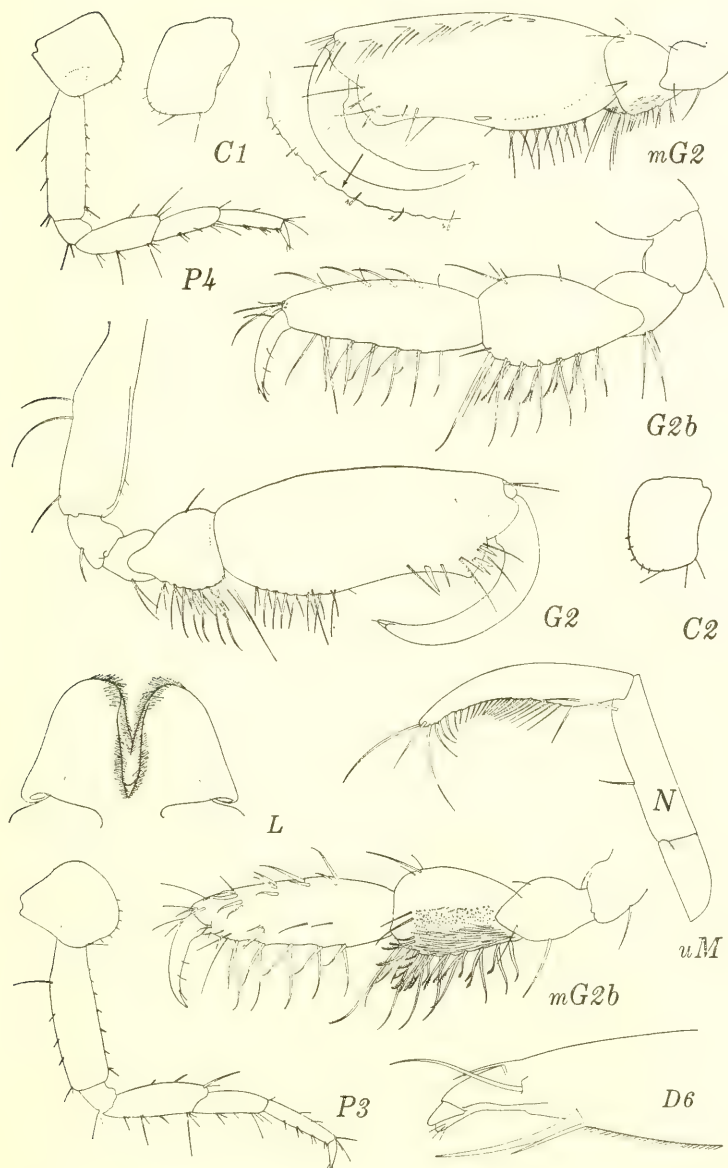


FIG. 3. *Protohadzia schoenerae* (Fox), male "a" 5.16 mm; b = female "b" 3.37 mm. See fig. 1 for symbols.

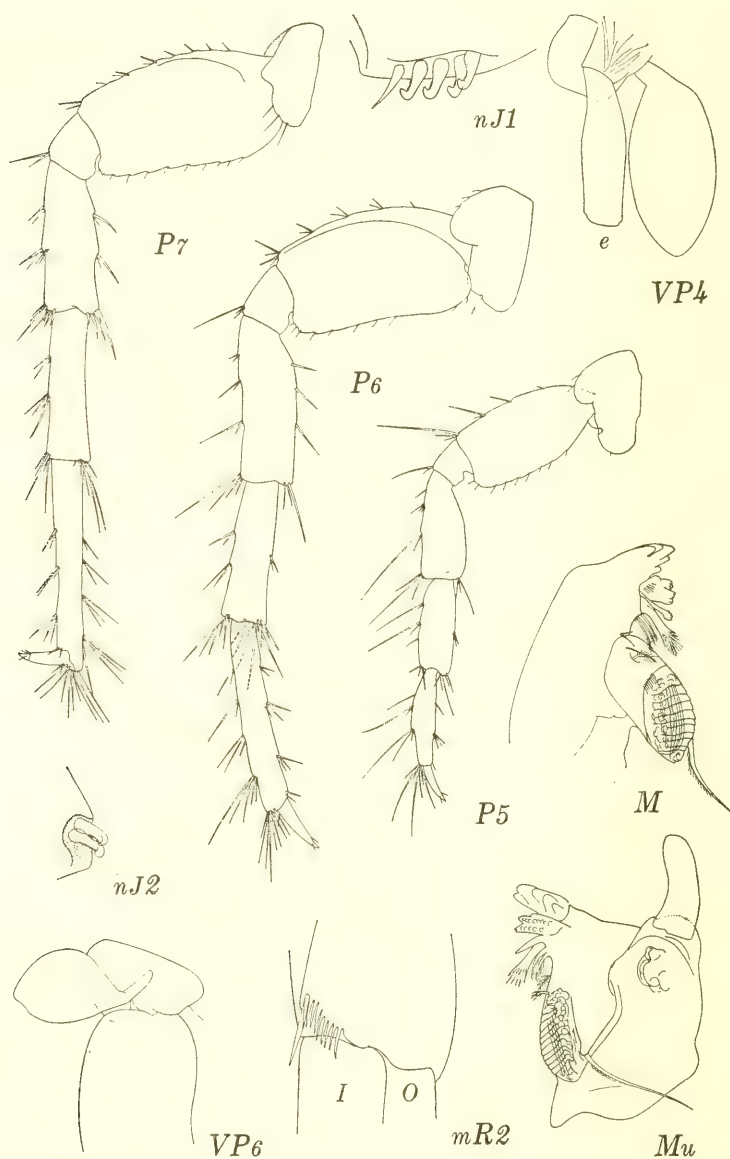


FIG. 4. *Protohadzia schoenerae* (Fox), male "a" 5.16 mm. See fig. 1 for symbols.

hadziids), lateral margin with 3 small dorsal spines and one enlarged (occasionally missing) fully apical spine, medial margin of peduncle with 3 dorsal spines, no enlarged apical spine, outer ramus naked dorsally, apex with nail and 3 accessory nails, inner ramus with 3 dorsal spines and similar apex, peduncle of uropod 2 with 6 dorsolateral spines, apicalmost weakly shifted to full apical position, medial apex with one dorsal spine and ventral comb of 7-9 fused spines, outer ramus with one dorsal spine, apical nail, 3 accessory nails and one spinule, inner ramus with 2 lateral and 4 medial spines and similar apex. Uropod 3 highly elongate, peduncle with one midventral spine laterally, one mid medial spinule, one apicomedial spine, 4 ventrolateral spines, inner ramus short, scale-like, pointed, attenuate, with either one subapical setule, or one stout spine plus one subapical setule, article 1 of outer ramus with 4 lateral acclivities plus apical declivity, spine formula from proximal end = 2-2-3-2-3, medial margin with 2 acclivities and apical declivity, spine formula = 2-2-3, article 2 about 0.20 times as long as article 1, with 2 subapical setules. Telson elongate, each apex narrow, bifid, each bearing lateral setule, long middle spine, short medial spine, lateral margins with 3 acclivities each bearing spine and setule, no medial spine. Coxal gills present on pereonites 2-6, pedunculate, those of pereonites 2-3 large and diamond-shaped, those of pereonites 4-5 elongate oval, that of pereonite 6 turned forward, short and ovate. Pleopods elongate, outer rami shorter than inner by one article of length, apical articles minute, each with 2 setae, outer rami with 6 articles, inner with 7, only peduncle of pleopod 3 with subapical setae. Urosomites lacking dorsal spines, urosomite 1 with spine at base of uropod 1. Cuticle with bulbar setules and striations in form of human unwhorled fingerprints (striations probably composed of tiny scale-serrations visible only under SEM).

Female: Article 5 of gnathopod 1 shorter than in male, lacking lateral and facial rows of elongate setae; gnathopod 2 much smaller than in male, of typical hadziid form, article 5 elongate, over 80 percent as long as article 6, palm and posterior margin of article 6 confluent, with sparse bundles of stiff, curved setae, lacking palmar protrusion, inner margin of dactyl with setules, no spines; article 4 of pereopod 5 with posterior spines, either one set of one spine plus setule or 2 sets of 2 and one spines, all longest anterior setae of pereopod 5 much shorter than in male.

Observations: Sterna of pleosome highly ventrad, epimeron 1 anteriorly merging with sternum, anterior margin plastered to belly and then fully fused, this pleonite 1 with anterior sleeve-like extension fitting obliquely along ventroposterior margin of pereonite 7, flexible, pulled downward in our illustration; setal formulas on article 2 of pereopods 1-4, long posteriors = 4-2-1-1, short posteriors = 1-2-5-4, long anteriors = 0, short anteriors = 2-2-8-9.

Females in hand smaller than males, therefore generally less spinose

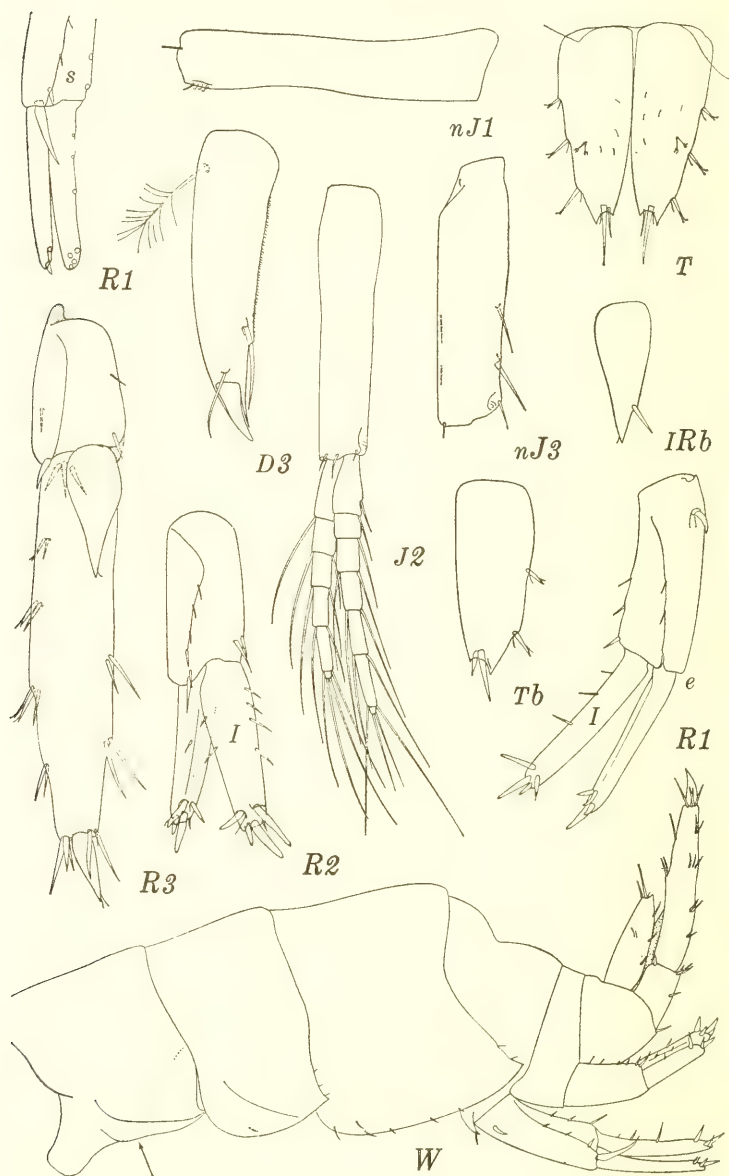


FIG. 5. *Protohadzia schoenerae* (Fox), male "a" 5.16 mm; b = female "b" 3.37 mm; arrow on W is point of attachment for pleopod 1. See fig. 1 for symbols.

and setose, especially in uropods, telson and epimera, for example epimeron 3 with only 3 ventral spines (5 in male), telson with only 2 lateral spine sets (each with one spine, one setule); gill of gnathopod 2 smaller relative to gill of pereopod 4 than in male; pleopods generally with fewer articles in rami, for example pleopod 2 of female "b" with 5 articles in each ramus on right side, on left side outer with 5, inner with 6 articles, peduncular hooks also fewer, for example pleopod 3 with 2 hooks in female, 4 in male.

Male "a" with only subapical setule on inner ramus of uropod 3 but 3 other specimens, one male and 2 females, with additional stout subapical spine on medial margin.

Voucher: USNM No. 154426, male "a" 5.16 mm long.

Locality: Puerto Rico, La Parguera, Corona Reef, 17°58'N, 67°03'W, intertidal, backreef area, in bed of *Thalassia testudinum*, 6 June 1975, coll. R. J. Zimmerman.

Remarks: Gnathopod 2 of our male "a" is better developed than the male shown by Fox (1973) but otherwise the two groups of specimens from Bimini and Puerto Rico, appear to be conspecific. Fox's drawing of the lower lip (his figure 8B) apparently is an aboral view, which we depict in our figure 1L. The oral view of our figure 3L shows that inner lobes are absent.

Distribution: Bahama Islands, Bimini lagoon; Puerto Rico, sublittoral, in *Thalassia* bed.

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PROCEEDINGS
OF THE
BIOLOGICAL SOCIETY OF WASHINGTON

A DISCRIMINANT FUNCTION ANALYSIS OF THE
FROGS OF THE GENUS *ADENOMERA* (AMPHIBIA:
LEPTODACTYLIDAE)

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A previous analysis of the systematics of the frogs of the genus *Adenomera* (Heyer, 1973) was completed without benefit of field experience or computer analysis. I have now had field experience with three species in the complex and have also learned that in at least one case, one of the species previously described is a composite of two species. The purpose of this paper is to apply a multivariate technique of analysis to data previously used in a variable by variable analysis to learn which method best determines: (1) species limits; and (2) patterns of geographic variation.

METHODS AND MATERIALS

The original data from the previous study (Heyer, 1973) are treated as follows. Data are used only for adults where complete information is available. The six variables of the original study are treated for computer analysis as follows. A) Snout-vent length (size) is entered as originally recorded. B) Dorsal pattern is not used because the states recognized previously do not show an orderly progression (Heyer, 1973, Fig. 2). The character has four more or less distinct patterns, dark striped, uniform, symmetrically spotted, asymmetrically spotted. In order for correlations to be made, which the discriminant function analysis does, the states must have a meaningful relationship to each other. That is, if the four pattern states were

coded as 1, 2, 3, 4, this implies that state 2 is derivable from state 3, or vice versa, etc. As simple inspection of the states does not allow relationships, derivability, or progressions to be made, and as there is no genetic information on the inheritance of color pattern for these frogs, the character is omitted from computer analysis. C) The three states of the dorsolateral stripes are coded as 1, no stripes; 2, light, narrow, stripes from eye to inguinal region; 3, light, broad, conspicuous stripes from eye to inguinal region. D) The original seven states recognized for middorsal stripes reduce to three states for computer analysis: 1, no stripe; 2, pin stripe extending from vent to sacrum or beyond; 3, broad stripe from vent to tip of snout. E) Snout shape ratio is entered as originally recorded (see Heyer, 1973, for determination of this ratio). F) The four states of toe tip expansion are coded from no expansion, 1, to large distinct disks, 4, according to the previous coding scheme (Heyer, 1973, Fig. 1). In the original study, intermediate toe tip categories were recorded. For coding purposes, wherever an intermediate state is encountered, the first state recorded is used (e.g. the intermediate state A-B as previously recorded would be coded as 1 here where $A = 1$, $B = 2$).

The data are analyzed using the BMD07M program, Stepwise Discriminant Analysis (Dixon, 1974). The use of discrete variables places the following restriction on interpretation of the results. The discriminant function analysis uses correlations. While calculation of correlation coefficients does not require normality, normality insures a valid test of significance if applied. (Having non-normally distributed data does not mean that a significance test is necessarily invalid, however.) As the variables used here are not all normally distributed, a statistical interpretation of the results is open to question. The immediate consequence of this is that the statistical information provided in the entering order of the variables should not be used as given. The first variable entered is that which has the greatest intergroup variation and the least intragroup variation. The second variable entered is that which has the next greatest intergroup variation and correlates best with the first variable entered, etc. Thus, the entering order of the variables provides important information. The program determines an approxi-

mate F statistic for each step so that a statistical determination can be made on which variables are adding information to the analysis and which are not; because discrete variables are used in this study, this information can not be statistically interpreted with certainty. This restriction does not invalidate the analysis itself. Correlation coefficients for non-normally distributed data are valid as long as there is a relationship among the data elements. For systematic studies, this restriction is not serious. The results of the analysis described here are valid; the results are repeatable. If someone else collected the data in the same way, the results would be the same. An unknown can be entered and classified. The results can be interpreted in biological terms, the only restriction is that statistical confidence limits or other statistical interpretations can not be made on or from the results.

The discriminant function program produces several data analyses and formats of results. Three portions of the discriminant function analysis are used in this study: (1) order of variables entered, (2) canonical variable analysis, (3) posterior classification of cases into groups. The order of variable entering has been commented on above. The first two canonical variables are plotted against each other, and it is the graphed results which are used here. For each data card entry, a posterior probability of belonging to each of the groups is determined and a classification based on this analysis is produced. For further explanation of terms, logic, and statistical procedures, see Dixon (1974).

Because there is sexual dimorphism in at least one character (size), data for males and females are analyzed separately.

RESULTS OF ANALYSIS

Species Limits: The discriminant function analysis requires that the groups be known on which the analysis takes place. In this case, the data cards are arranged into groups corresponding with the species limits previously recognized, that is, the species *Adenomera andreae*, *bokermanni*, *hylaedactyla*, *marmorata*, and *martinezi*. Not enough data are available for the recently described *A. lutzi* (Heyer, 1975) for computer analysis and only enough data for females of *martinezi* are available for analysis.

For females, sample sizes for the groups are: *andreae*, 197; *bokermanni*, 27; *hylaedactyla*, 175; *marmorata*, 102; *martinezi*, 14. The variables

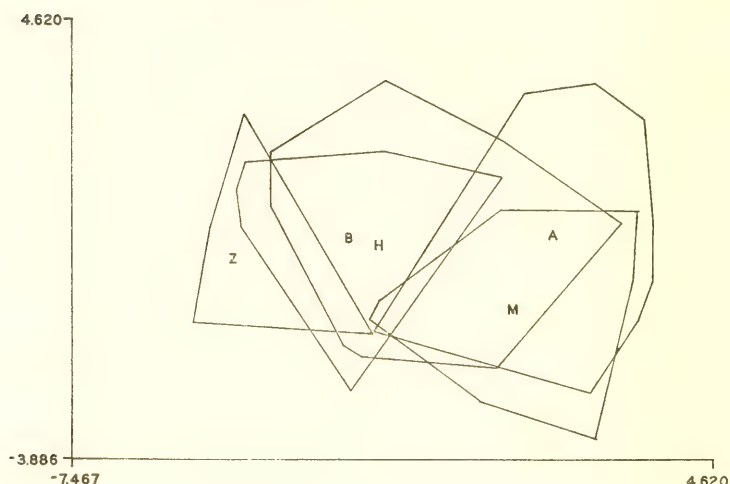


FIG. 1. Plot of first against second canonical variables for females of the genus *Adenomera*. A = *A. andreae*, B = *A. bokermanni*, H = *A. hylaedactyla*, M = *A. marmorata*, Z = *A. martinezi*. Letters are placed at group means. Envelopes contain all group members.

enter in the following order: toe disks, size, snout shape, middorsal stripe, dorsolateral stripe. Almost all of the variation is accounted for by the first variable (F values can give a comparative idea, although can not be statistically interpreted. The F value for the first variable entered, toe disks, is 346, the F value for the next step entered, size, is 17; remaining F values are smaller). The results of the canonical analysis (Fig. 1) show moderate, but certainly not complete, separation of the groups. The first canonical variable accounts for 90% of the total dispersion, the first two canonical variables account for 97% of the total dispersion. The posterior classification of cases into group results (Table 1) clarifies the canonical analysis as presented in Fig. 1. It is clear that the five variables are sufficient to separate *martinezi* from all the others, *andreae* from *hylaedactyla*, and *bokermanni* from *marmorata*. Most classification errors involve *bokermanni*-*hylaedactyla* and *andreae*-*marmorata*.

For males, sample sizes for the groups are: *andreae*, 73; *bokermanni*, 29; *hylaedactyla*, 76; and *marmorata*, 80. The variables enter in the following order: toe disks, size, middorsal stripe, dorsolateral stripe, snout shape. Almost all of the variation is accounted for by the first variable with virtually all variation accounted for by the first two variables. The canonical analysis results (Fig. 2) are similar to the female results. The first canonical variable accounts for 85% of the

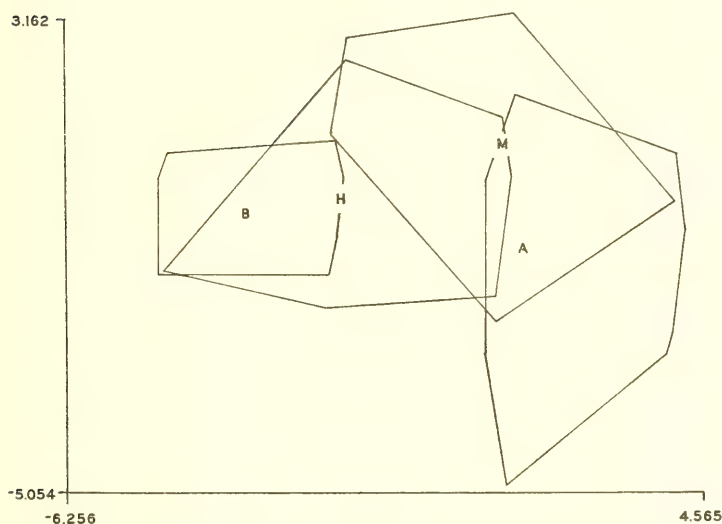


FIG. 2. Plot of first against second canonical variables for males of the genus *Adenomera*. A = *A. andreae*, B = *A. bokermanni*, H = *A. hylaedactyla*, M = *A. marmorata*. Letters are placed at group means. Envelopes contain all group members.

total dispersion; the first two canonical variables account for 99% of the total dispersion. The posterior classification (Table 2), while generally comparable to the female results is different in two ways. First, more males are correctly classified to group than females. This indicates that males are easier to identify than females for the variables used. Second, while the separation of *andreae* from *marmorata* involves the same kind of classification errors as for females, the same is not true for *boker-*

TABLE 1. Posterior classification of females of the genus *Adenomera*.

Group	Number (percent) of cases classified into group				
	<i>martinezi</i>	<i>andreae</i>	<i>hylaedactyla</i>	<i>marmorata</i>	<i>bokermanni</i>
<i>martinezi</i>	13(93)	0	0	0	1 (7)
<i>andreae</i>	0	145(74)	1 (0)	51(26)	0
<i>hylaedactyla</i>	5 (3)	3 (2)	114(65)	9 (5)	44(25)
<i>marmorata</i>	0	19(19)	2 (2)	81(79)	0
<i>bokermanni</i>	4(15)	1 (4)	8(30)	0	14(52)

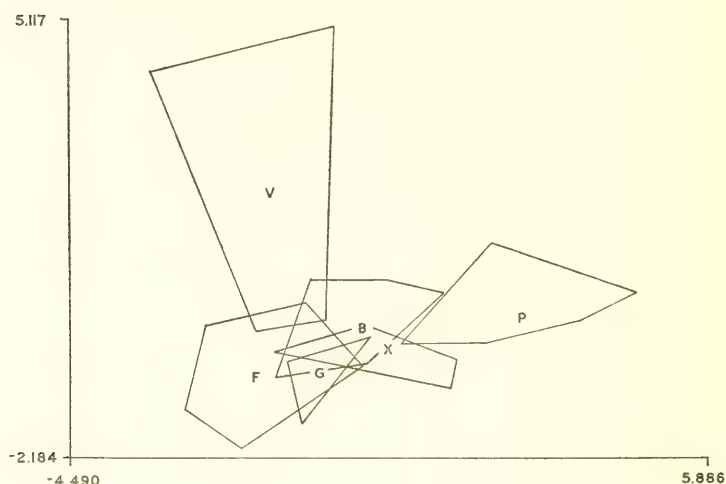


FIG. 3. Plot of first against second canonical variables for geographic samples of males of *Adenomera hylaedactyla*. B = Bolivia, Santa Cruz; X = Brasil, Amazonas; V = Brasil, Rondônia; F = French Guiana; G = Guyana, Essequibo; P = Peru, Huanuco. Letters are placed at group means. Envelopes contain all group members.

manni and *hylaedactyla*. Very few *hylaedactyla* are classified as *bokermanni*, while many *bokermanni* are classified as *hylaedactyla*.

In an analysis of this sort, the groups should be completely separated by the graphic canonical variable analysis (e.g. Figs. 1 and 2) and the posterior classification should yield 100% correct classifications. The results of this analysis are not this clear-cut or convincing. The following recently gathered information is pertinent to a meaningful interpretation of the results. I have had the opportunity to have field experience with the following three taxa as used previously (Heyer, 1973): *A. an-*

TABLE 2. Posterior classification of males of the genus *Adenomera*.

Group	Number (percent) of cases classified into group			
	<i>andreae</i>	<i>hylaedactyla</i>	<i>marmorata</i>	<i>bokermanni</i>
<i>andreae</i>	59(81)	0	13(18)	1 (1)
<i>hylaedactyla</i>	3 (4)	68(89)	3 (4)	2 (3)
<i>marmorata</i>	12(15)	3 (4)	65(81)	0
<i>bokermanni</i>	0	13(45)	0	16(55)

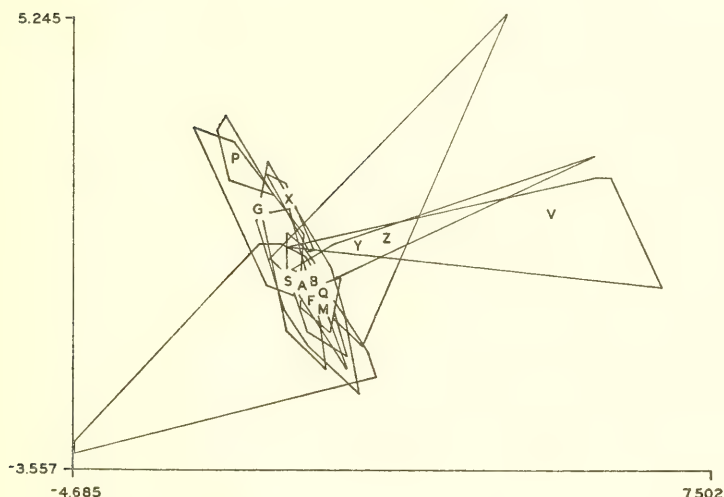


FIG. 4. Plot of first against second canonical variables for geographic samples of females of *Adenomera hylaedactyla*. A = Bolivia, Beni; B = Bolivia, Santa Cruz; Z = Brasil, Acre; Y = Brasil, Amapa; X = Brasil, Amazonas; V = Brasil, Rondônia; F = French Guiana; G = Guyana, Essequibo; Q = Peru, Junin; P = Peru, Pasco; S = Surinam; M = Venezuela, Monagas. Letters are placed at group means. Envelopes contain all group members.

dreae, *hylaedactyla*, and *marmorata*. *Adenomera andreae* and *hylaedactyla* occur together over a wide geographic area: *A. andreae* is a diurnal forest floor species, *A. hylaedactyla* is a nocturnal open formation species. There is no confusing these species in the field. The results of this study show that the two species are morphologically separable also. *Adenomera marmorata* was observed in the state of São Paulo. The species occurs both in forest and open formations (heavy grass) and calling occurs during and after rains irrespective of time. I am convinced that *andreae* and *marmorata* are distinct species, although the results of this study indicate that there is a fair amount of morphological overlap between them. Werner C. A. Bokermann and Eugenio Izecksohn (pers. comms.) have informed me that the species I described as *bokermanni* is a composite of two morphologically similar species. Data for the males (Table 2) show this quite clearly. Because two species are involved, the posterior classification into groups was poor for *bokermanni*. The posterior identification errors between *andreae* and *marmorata* suggest that *marmorata* may also be a composite species, but the evidence is not as clear as for *bokermanni*. Nothing

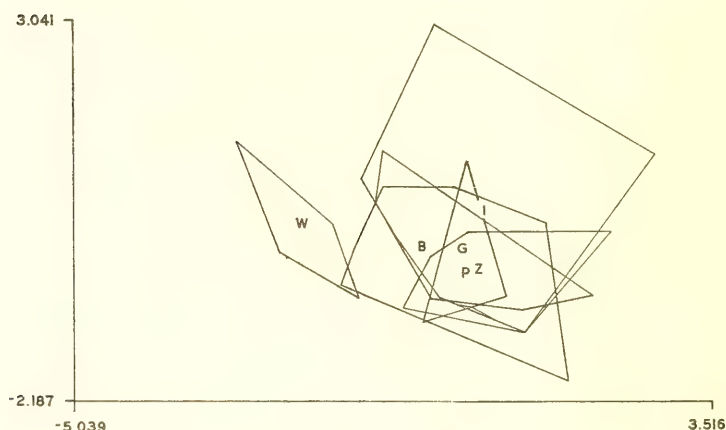


FIG. 5. Plot of first against second canonical variables for geographic samples of males of *Adenomera andreae*. B = Bolivia, Santa Cruz; W = Brasil, Para; 2 = Ecuador, Napo; 1 = Ecuador, Pastaza; G = Guyana, Essequibo; P = Peru, Loreto. Letters and numbers are placed at group means. Envelopes contain all group members.

further can be done presently with the data to resolve these questions as the specimens are no longer at hand and sample sizes for *bokermanni* and *marmorata* are too small to analyze on a geographic basis as is done for *andreae* and *hylaedactyla*.

Geographic Variation: For analysis of geographic variation, each group consists of at least three specimens from a single locality. For only two species are there enough specimens from enough localities to analyze in this way.

The following localities (specific locality information not included here as it is not necessary for present purposes) and sample sizes comprise the groups for male *A. hylaedactyla*: Bolivia, Santa Cruz, 9; Brasil, Amazonas, 4; Brasil, Rondônia, 6; French Guiana, 11; Guyana, Essequibo, 4; Peru, Huanuco, 7. The order of variable entering (and F values, again included to add a dimension of importance, not statistical significance) is: size (12.8), toe disks (5.5), snout shape (4.0), mid-dorsal stripe (1.0), dorsolateral stripes (0.6). Any patterns of variation should be demonstrated by the canonical variable analysis (Fig. 3). The first two canonical variables describe 94% of the total dispersion, the first variable accounting for 65%. The samples from Rondônia and Peru are distinctive from the other samples and distinctive from each other (Fig. 3).

The following localities and sample sizes comprise the groups for female *A. hylaedactyla*: Bolivia, Beni, 24; Bolivia, Santa Cruz, 12; Brasil,

Acre, 5; Brasil, Amapa, 4; Brasil, Amazonas, 3; Brasil, Rondônia, 5; French Guiana, 51; Guyana, Essequibo, 7; Peru, Junin, 4; Peru, Pasco, 5; Surinam, 5; Venezuela, Monagas, 6. The order of variable entering and (F values) is: toe disks (11.3), size (7.2), middorsal stripe (4.2), snout shape (2.2), and dorsolateral stripe (1.6). The first canonical variable accounts for 45% of the total dispersion, the first two variables account for 78% (Fig. 4). The sample from Brasil, Rondônia is most distinctive, the populations from Brasil, Amapa and Brasil, Acre are moderately distinct from other samples and similar between themselves.

The differences in variable entering and graphic representation of canonical variables may be due to the different sample sizes involved. No meaningful pattern of geographic variation is evident for either male or female *A. hylaedactyla* from the results as represented in Figs. 3 and 4.

The following localities and sample sizes comprise the groups for male *A. andreae*: Bolivia, Santa Cruz, 12; Brasil, Para, 5; Ecuador, Napo, 7; Ecuador, Pastaza, 18; Guyana, Essequibo, 6; Peru, Loreto, 5. The order of variable entering (and F values) is: size (4.6), snout shape (1.0), middorsal stripe (0.8), toe disks (0.6), dorsolateral stripes (0.6). The first canonical variable accounts for 72% of the total dispersion, the first two canonical variables account for 87%. The sample from Brasil, Para is distinctive (Fig. 5).

The following localities and sample sizes comprise the groups for female *A. andreae*: Bolivia, Santa Cruz, 16; Brasil, Amapa, 5; Brasil, Amazonas, 6; Brasil, Amazonas, 15; Brasil, Para, 18; Brasil, Rondônia, 4; Colombia, Meta, 6; Ecuador, Morona, 8; Ecuador, Napo, 10; Ecuador, Napo, 23; Ecuador, Pastaza, 5; Ecuador, Pastaza, 10; Ecuador, Pastaza, 6; French Guiana, 5; Guyana, Essequibo, 8; Peru, Loreto, 6; Surinam, Marowijne, 4; Surinam, Suriname, 8. The order of variable entering (and F values) is: size (10.9), middorsal stripe (3.8), snout shape (2.6), toe disks (2.4), dorsolateral stripes (1.8). The first canonical variable accounts for 54% of the total dispersion, the first two account for 74%. No clear pattern of geographic variation is evident from the plot of the first two canonical variables (Fig. 6).

The results for male and female *A. andreae* are similar. No pattern of geographic variation is evident from the results as represented in Figs. 5 and 6.

DISCUSSION

The number of variables used in this analysis is minimal. Except for dorsal pattern, which poses a coding problem, they are the only variables available for analysis from external morphology because all of the frogs of this study have a basic morphological similarity. For the kinds of characters available in frogs, use of multivariate techniques is concluded to be suitable in determining species limits but not in evaluating patterns of geographic variation. As the earlier study (Heyer,

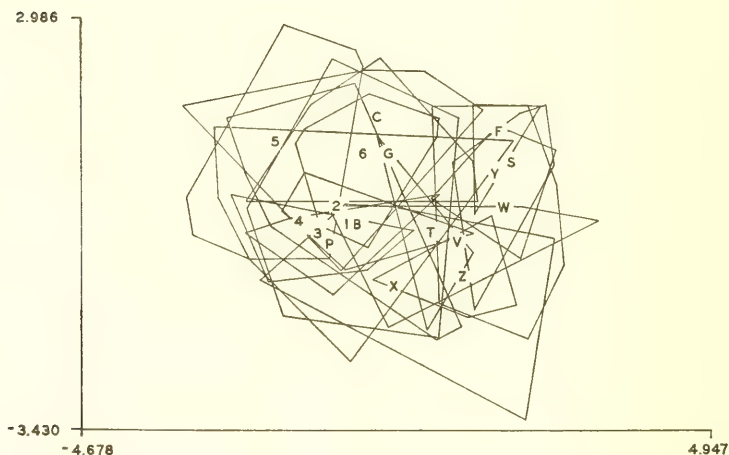


FIG. 6. Plot of first against second canonical variables for geographic samples of females of *Adenomera andreae*. B = Bolivia, Santa Cruz; Z = Brasil, Amapa; Y = Brasil, Amazonas; X = Brasil, Amazonas; W = Brasil, Para; V = Brasil, Rondônia; C = Colombia, Meta; 6 = Ecuador, Moruna; 5 = Ecuador, Napo; 4 = Ecuador, Napo; 3 = Ecuador, Pastaza; 2 = Ecuador, Pastaza; 1 = Ecuador, Pastaza; F = French Guiana; G = Guyana, Essequibo; P = Peru, Loreto; T = Surinam, Marowijne; S = Surinam, Suriname. Letters and numbers are placed at group means. Envelopes contain all group members.

1973) found patterns of geographic variation, a more detailed comparison is necessary to determine why this study differs in this respect from the previous one.

Previously, the characters of dorsal pattern, dorsolateral stripes, and middorsal stripes were shown to demonstrate meaningful geographic variation in *A. hylaedactyla* (Heyer, 1973). In this study, dorsal pattern information could not be coded and the information content of mid-dorsal stripes was greatly reduced in coding for computer analysis. The characters which had the greatest intergroup variation in this study are size and toe disks; it is not surprising that these characters do not show any patterns of geographic variation here as they were previously found not to vary geographically. For *A. andreae*, the previous analysis (Heyer, 1973) showed that dorsal pattern, middorsal stripe pattern and size varied geographically. Only one of these, size, shows much intergroup variation in the present analysis, but the results are not interpretable in terms of geographic variation.

Most of the information which demonstrated geographic variation in the previous study could not be employed in this analysis due to re-

strictions in the kinds of character states that can be used in a discriminant function analysis or any other in which the basic analytic method involves correlations. For the kinds of data available on certain groups of frogs, it would appear that the best use of multivariate techniques is to aid in species limit determinations, but not in describing geographic variation within a species.

ACKNOWLEDGMENTS

Dr. Charles D. Roberts, Smithsonian Institution, has been extremely patient and helpful in introducing me to the use of multivariate analyses. I thank Dr. P. E. Vanzolini for pointing out several limitations involved in using multivariate techniques; we still differ with respect to whether discrete variables can be validly analyzed by multivariate techniques, however. Ms. Susan Arnold transformed the data from the original form to computer cards. Dr. George R. Zug criticized the manuscript.

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PROCEEDINGS
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TWO NEW GENERA AND A NEW SUBFAMILY OF
BODOTRIIDAE (CRUSTACEA: CUMACEA) FROM
EASTERN NORTH AMERICA

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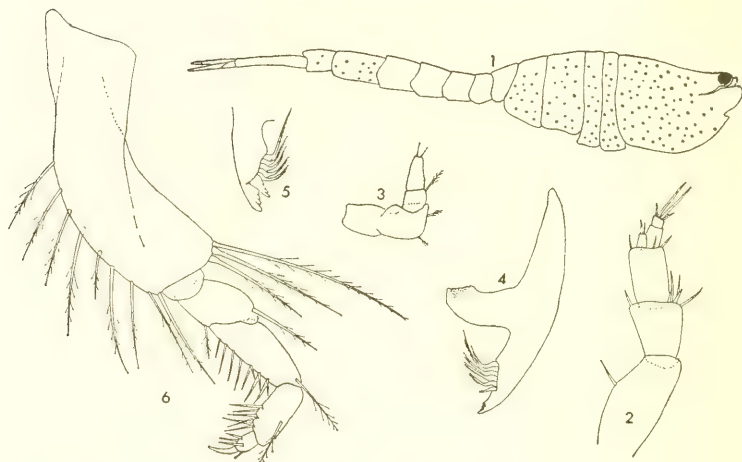
Only three species of the Bodotriidae, currently assigned to the Subfamily Vaunthompsoniinae, are known in which the males have less than five pairs of pleopods. All of these were described from North American Atlantic coastal and brackish waters: *Leptocuma minor* Calman, 1912; *Mancocuma stellifera* Zimmer, 1943; and *M. altera* Zimmer, 1943. The *Manocuma* species have two pairs of reduced pleopods, while Calman's *L. minor* possesses three pairs of fully developed pleopods. Hale (1944) noted that *L. minor* should be removed from the genus *Leptocuma* and later Jones (1973) suggested that it be included in the genus *Mancocuma*.

In this paper, the new genus *Pseudoleptocuma* will be proposed for Calman's species and an additional new genus characterized by the lack of pleopods in the male will be described. The new subfamily, Mancocuminae, is proposed for these bodotriid genera with reduced numbers of pleopods.

Mancocuminae, new subfamily

Diagnosis: Bodotriidae with the following features: less than 5 pairs of pleopods in male; at least 3 pairs of pereopods with exopods in both sexes; mandible with few (approximately 6) spines between incisor and molar processes; uropod endopod with 2 articles.

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FIGS. 1-6. *Spilocuma salomani*, new species, female: 1, Side view of body; 2, Antenna 1; 3, Antenna 2; 4, Right mandible; 5, left mandible, tip; 6, Third maxilliped.

Type-genus: *Mancocuma* Zimmer, 1943.

Remarks: The Family Bodotriidae previously consisted of two subfamilies, the Bodotriinae, which have exopods only on the first pair of pereopods in either sex, and the Vaunthompsoniinae, which have exopods on at least the first 2 pairs of pereopods. With the exception of the 3 North American species, all species in both subfamilies have males with 5 pairs of pleopods. The new subfamily Mancocuminae is proposed for the following genera: *Mancocuma* Zimmer, 1943; *Pseudoleptocuma* nov.; *Spilocuma* nov.

***Pseudoleptocuma*, new genus**

Diagnosis: Male with 3 pairs of pleopods, each of which has a process on endopod outer margin; female with well developed exopods on pereopods 1-3 and a rudimentary exopod on pereopod 4; male with well developed exopods on pereopods 1-4; male antenna 2 with flagellum reaching to end of pleon; distal external angle of maxilliped 3 basis produced; pereopod 1 with distal brush of setae on propodus and dactylus.

Type-species: *Leptocuma minor* Calman, 1912.

Remarks: The differences between *P. minor* (Calman) and all species of *Leptocuma* (except *L. forsmanni* Zimmer) were discussed by Hale (1944). Most of these differences are embodied in the diagnosis of the



FIGS. 7-10. *Spilocuma salomani*, new species: 7, Pereopod 1, female; 8, Uropod, female; 9, Antenna 1, male; 10, Uropod, male.

new genus. *Pseudoleptocuma* is quite similar to *Mancocuma* but differs from it in the number and development of the pleopods in the male, in the development of the male second antenna flagellum, and in the elongate form of the pereopod 1 propodus.

Spilocuma, new genus

Diagnosis: Well developed exopods on pereopods 1-3 and a rudimentary exopod on pereopod 4 in both sexes; male without pleopods; male antenna 2 with strongly reduced flagellum; distal external angle of maxilliped 3 basis not produced; pereopod 1 without distal brush of setae on propodus and dactylus.

Type-species: *Spilocuma salomani* n.

Remarks: This genus differs from all other Bodotriidae in its lack of pleopods in the male, but it possesses the following combination of features which characterize this family: mandible normal with large triturating molar; pereopods 1-4 with exopods in both sexes; uropod endopod of 2 articles. *Spilocuma* differs from both *Mancocuma* and *Pseudoleptocuma* in having a rudimentary exopod on pereopod 4, the distal external angle of the third maxilliped basis not produced, and in lacking the distal brush of setae on pereopod 1 propod and dactyl.

Etymology: Prefix derived from the Greek *spilos* = a spot, blemish.

Spilocuma salomani, new species

Figures 1-13

Description: Adult female. Length, 4.0 mm. Carapace with pseudo-rostral lobes extending only a short distance in front of ocular lobes; infero-lateral edge smooth, with small antennal sinus. All thoracic somites visible in thoracic view. Cephalothorax, with exception of fifth thoracic somite, and last 2 pleonal somites covered with chromatophores. Five pedigerous somites together as long as carapace and $\frac{2}{3}$ as long as pleon.

Antenna 1 first peduncle article as long as second and third articles together; main flagellum of 2 articles which together are half as long as third peduncle article; accessory flagellum uniarticulate, shorter than first main flagellum article.

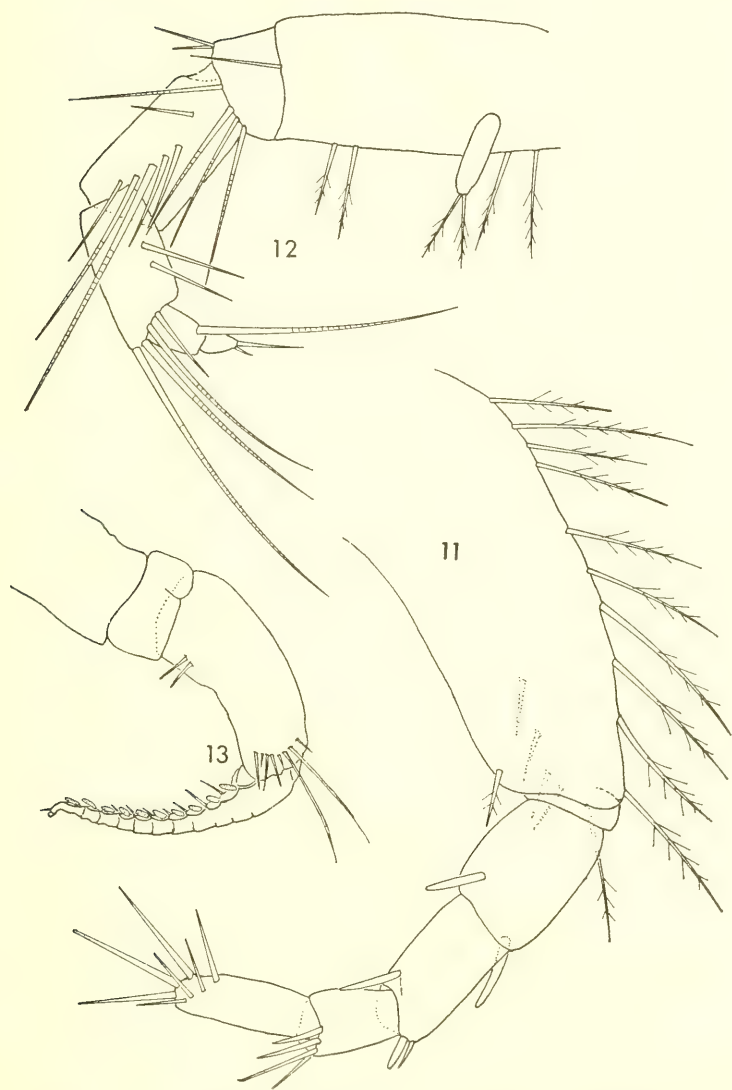
Antenna 2 small, consists of 3 articles; basal article indistinctly jointed.

Mandible of normal shape, molar process large and triturating; 5 recurved spines along inner margin between incisor and molar processes.

Third maxilliped basis distal external angle not produced, armed with 3 long plumose setae; merus with single plumose seta on distal external angle; carpus slightly longer than propodus, armed on ventral margin with long stiff setae; propodus with group of strong spines distally along ventral margin; dactylus much shorter than propodus, armed terminally with stout, recurved spine.

First pereopod basis longer than distal articles together; carpus and propodus subequal in length, carpus only slightly wider than propodus; dactylus half length of propodus, armed terminally with 2 spines.

Second pereopod of 7 articles, ischium very short; carpus and merus subequal in length, merus slightly narrower; dactylus longer than propodus, subequal in length to carpus and merus, armed terminally with 3 strong spines.



FIGS. 11-13. *Spilocuma salomani*, new species: 11, Pereopod 2, female; 12, Pereopod 4, female; 13, Antenna 2, male.

Fourth pereopod with rudimentary exopod; propodus and dactylus together shorter than carpus.

Uropod endopod of 2 articles, distal article one-third as long as basal; basal article armed along inner margin with 9–12 stout, serrated spines, terminal articles with 3 lateral and 1 terminal, serrated spines; exopod with 5 lateral and 3 terminal, strong, simple spines.

Adult Male. Length, 2.0 mm. Body similar in overall appearance to adult female; chromatophores present only on carapace, giving a banded appearance. Males obtained were grasping ovigerous females when collected.

Antenna 1 main flagellum of 3 articles, second article twice length of first; accessory flagellum uniaarticulate and slightly longer than basal flagellar article.

Antenna 2 strongly modified for grasping, flagellum recurved and only slightly longer than last peduncle article; flagellum indistinctly jointed, each article bearing flattened, granulated pad on its ventral side.

Uropod exopod armed only with 2 lateral and 2 terminal setae; endopod basal article inner margin armed with 12–15 stout, serrated spines; peduncle inner margin armed with 6 or 7 long, stiff setae.

Etymology: This species is named in honor of Dr. Carl Saloman, NMFS, Gulf Coastal Fisheries Center, Panama City, Florida, who kindly sent several lots of specimens and who has carefully documented their occurrence.

Type-locality: Off Panama City Beach, Florida, 85°46' W, 30°10' N; depth, 3 m.

Material examined: 27 individuals from the type-locality.

Holotype: USNM No. 156320; male.

Paratypes: USNM No. 156321; 7 females and 4 males.

ACKNOWLEDGMENTS

The author would like to express his appreciation to Dr. Carl Saloman for bringing this material to his attention.

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PROCEEDINGS
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REVIEW OF THE INDO-PACIFIC PIPEFISH GENUS
LISSOCAMPUS (SYNGNATHIDAE)

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My studies of the catch-all genus *Ichthyocampus* Kaup show that a number of nominal species assigned to *Ichthyocampus* are referable to other genera. I herewith review the genus *Lissocampus* Waite and Hale and include therein three species formerly placed in *Ichthyocampus*. Study material is limited but I have examined the pertinent types and illustrated each species. Other species now referred to *Ichthyocampus* will be treated in subsequent reports.

In *Lissocampus*, the anteriormost dorsal-fin ray is often obscured by the surrounding membrane. Length of dorsal-fin base is therefore here defined as: distance between anteriormost indication of elevated fin base and insertion of posteriormost fin ray. Other counts and measurements follow Dawson (1976). Color descriptions are from specimens preserved in alcohol; materials examined are usually listed only by general locality; depth is reported in meters (m).

Abbreviations for repositories of examined material: AMS—Australian Museum, Sydney; ANSP—Academy of Natural Sciences, Philadelphia; BMNH—British Museum (Natural History); BPBM—Bernice P. Bishop Museum; CAS—California Academy of Sciences; GCRL—Gulf Coast Research Laboratory Museum; HUJ—Hebrew University of Jerusalem; NMNZ—National Museum of New Zealand, Wellington; QVM—Queen Victoria Museum, Launceston, Tasmania; SAM—South Australian Museum, Adelaide; USNM—National Museum of Natural History, Smithsonian Institution; WAM—Western Australian Museum, Perth.

Lissocampus Waite and Hale

Lissocampus Waite and Hale, 1921:306 (type-species: *Lissocampus caudalis* Waite and Hale, 1921, by original designation).

Larvicampus Whitley, 1948:75 (type-species: *Festucalex* (*Campichthys*) *runa* Whitley, 1931, by original designation).

Diagnosis: Superior trunk and tail ridges continuous; lateral trunk ridge continuous with inferior tail ridge; inferior trunk and tail ridges discontinuous near anal ring; median dorsal snout ridge low to distinctly elevated; opercular and other head ridges vestigial or obsolete; no ridges on pectoral-fin base; scutella oval, without keels; body ridges inconspicuous, little indented between rings; trunk somewhat V-shaped ventrad, without median longitudinal keel; devoid of spines or serrae, with or without dermal flaps. Dorsum of trunk and tail somewhat convex; venter of tail often convex; dorsal-fin base elevated anteriorly, adjacent surfaces of subdorsal rings sloped upward (Fig. 5); dorsal-fin membrane not closely bound throughout to fin rays, somewhat voluminous over basal third or half of fin and usually distinctly enlarged or sac-like in front. Head length (HL) 10.8–14.4 in standard length (SL); snout length 2.6–4.0 in head length; trunk rings 13–17; rings total 50–74; subdorsal rings 2.25–4.25, dorsal-fin origin on trunk; dorsal-fin rays 13–19; pectoral-fin rays 5–13; anal fin present; caudal-fin rays 10. Brood pouch under tail, without protective plates; brood-pouch eggs in 3–4 transverse rows (usually 2 layers deep) covered by protective folds which meet or nearly meet on ventral midline. Without odontoid processes in jaws (Dawson and Fritzsche, 1975); nares 2-pored bilaterally. Maximum size at least 132 mm SL. Red Sea, Australia, Tasmania, New Zealand and Chatham Is.; marine.

Comparisons: Among syngnathine (tail pouch) pipefishes, the *Lissocampus* configuration of principal body ridges is shared with *Penetopteryx* Lunel, *Urocampus* Günther and the western Atlantic *Ichthyocampus pawnee* Herald. The anal fin is absent in the latter species and *Penetopteryx* lacks dorsal, anal and pectoral fins (these fins present in *Lissocampus*). *Urocampus* and the somewhat similar *Siokunichthys* resemble *Lissocampus* in general appearance but the dorsal-fin base is not elevated in these genera and the dorsal fin originates on tail (fin base elevated anteriorly in *Lissocampus*, dorsal-fin origin on trunk).

Remarks: Waite and Hale (1921) diagnosed *Lissocampus* "without ridges" and this error was not corrected by subsequent authors (Munro, 1958; Scott, 1961, 1971). Body rings and ridges cannot be seen clearly on wet specimens and this may in part explain differences between published accounts and present observations from near-dry material; other discrepancies result from different methods of enumerating rings, etc. Difficulty may also occur in obtaining accurate counts of dorsal-fin rays, since one or more anterior rays may be concealed within the surrounding sac-like membrane. The membrane forms a swollen and somewhat turgid protuberance in many preserved specimens; in others, the space between

right and left membranes often entraps quantities of air when specimens are removed from preservative. Function of this dorsal-fin modification is unknown; it may be inflatable and could serve as a hydrostatic organ. In any event, I am unaware of a similar specialization in other syngnathids. Anal-fin rays 3–4, fin minute and, in mature males, concealed within the brood pouch.

Pouch folds are voluminous in males with well-developed eggs, but some eggs remain exposed since folds (in preserved material) fail to meet on ventral midline. Where eggs appear to be newly laid, pouch folds meet on midline and closure is the everted type of Herald (1959). Some males, without eggs, have folds rolled bilaterally inward in scroll-like fashion, and these fish may have recently discharged their brood.

Dermal flaps are present in all examined *L. bannwarthi* but flaps are variously present or absent in other species, without apparent correlation with standard length or sex. In some specimens, the persistent bases of dermal flaps appear as pimplelike projections. Flaps are often simple but may be branched or leaflike; Scott (1961) described variations in branching of “barbels” or mandibular flaps in *L. caudalis* from Tasmania.

KEY TO THE GENUS LISSOCAMPUS

1. Trunk rings 12–15; dorsal-fin rays 13–15; pectoral-fin rays 5–8 2
 Trunk rings 17; dorsal-fin rays 18–19; pectoral-fin rays 11–13 *bannwarthi*
2. Profile of snout straight, snout ridge high 3
 Profile of snout concave, snout ridge low 4
3. Tail rings 51–60; pectoral-fin rays modally 5 *caudalis*
 Tail rings 44–47; pectoral-fin rays modally 7 *fatiloquus*
4. Trunk rings 13–15, modally 14; subdorsal rings total 2.75–3.5, modally 3.25; brood pouch usually below 14–16 tail rings; New Zealand and Chatham Is. *filum*
 Trunk rings 13–14, modally 13; subdorsal rings total 2.25–3.0, modally 2.75; brood pouch usually below 12–13 tail rings; Australia and Tasmania *runa*

Lissocampus caudalis Waite and Hale

Figure 1

Lissocampus caudalis Waite and Hale, 1921:306, fig. 46 (Kangaroo Is., South Australia).

Diagnosis: Profile of snout essentially straight dorsad; margin of median dorsal snout ridge usually above or in line with dorsal margin of orbit; total rings 64–74; pectoral-fin rays modally 5.

Description: Dorsal-fin rays 13–14; rings 12–14 + 51–60 = 64–74; subdorsal rings 0.5–1.25 + 1.25–1.75 = 2.25–2.50; pectoral-fin rays 5–6, modally 5; see Tables 1–3 for additional counts. Proportional data based

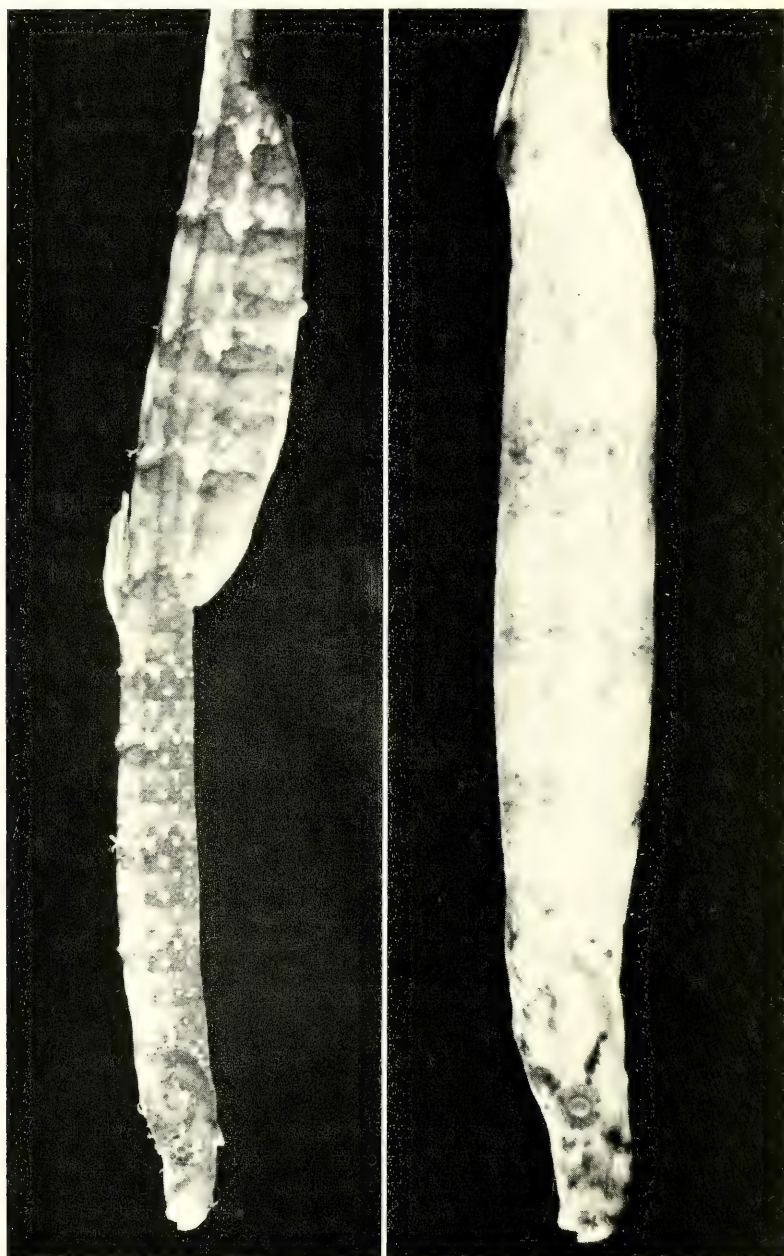


FIG. 1. Head and anterior body of *Lissocampus caudalis* QVM 1972/5/714. Top: Male, 80 mm SL. Bottom: Female, 75 mm SL.

on 5 Tasmanian specimens 70–90 ($\bar{x} = 78.1$) mm SL follow: HL in SL 12.7–14.0 (13.24); snout length in HL 3.0–3.4 (3.26); snout depth in snout length 1.3–1.4 (1.36); length of dorsal-fin base in HL 2.2–2.6 (2.42); anal ring depth in HL (3 fish) 3.2–3.4; pectoral-fin length in HL 3.4–3.8.

Gape subvertical; profile of head somewhat elevated behind eye but without distinct crest or ridges; operculum without ridge but surface waffled by low intersecting striae; pectoral-fin base 4–5 in pectoral-fin length. Dermal flaps simple to rather profusely branched; flaps may occur as follows: rather large flap, bilaterally, below angle of gape (mandibular flap); ring of minute simple flaps on eye; simple slender flap on dorsum of snout ridge above nares, one on dorsal rim of orbit, two on middorsal line of head, three on dorsolateral margin above opercle and one median flap on anterior third of opercle; flaps, often branched, on superior body ridges at about every 4th ring; lateral trunk ridge with branched flaps on every 4th ring and with smaller simple flaps on intervening rings. Anal-fin rays 3–4 in three specimens counted. Brood pouch below 13–16 tail rings in 3 males 76–90 mm SL, one (Fig. 1) contained about 49 eggs in pouch.

Dorsal-fin with brown blotch or bar anteriad, rays elsewhere plain or flecked with brown; caudal and pectoral fins plain or flecked with brown. Body coloration variably tan to dark brown (Fig. 1), markings brown or white; well-pigmented specimens with diffuse brown bands (best seen on dorsum) separated by similarly diffuse tan or white interspaces; sides and venter of trunk often flecked or spotted with white; brood-pouch folds with indications of irregular narrow white bars.

Comparisons: The snout ridge of *Lissocampus caudalis* is higher than that of any congener and this species also has the highest tail ring counts (51 or more against 49 or less). The straight snout ridge is shared with *L. fatiloquus* but these species differ in counts of pectoral-fin rays (modally 5 against 7 in *fatiloquus*) and other characters. See *L. fatiloquus* for further comparisons.

Remarks: The female holotype has only 12 trunk rings but appears to be atypical; the rear margin of the last trunk ring is angled caudad, rather than subvertical, and anal fin insertion is near middle of 1st tail ring, rather than near vertical from its anterodorsal margin. Caudal fin is damaged but there appear to be 10 rays, and there seem to be 4 basal elements in the minute anal fin. The snout ridge extends above level of dorsal margin of orbit; vestiges of dermal flaps persist on eye, rim of orbit, middorsal line of head, above opercle, and on most trunk rings; mandibular flaps are lacking; no evidence of color pattern remains. Measurements (mm) follow: SL 95.0, HL 6.3, snout length 1.9, snout depth 1.6, length of dorsal-fin base 3.1, anal ring depth 2.1, pectoral-fin length 1.9, length of pectoral-fin base 0.5; see Tables 1–3 for counts.

Total ring counts of the type-material (71–74) are higher than that of compared Tasmanian fish (64–68) and additional study specimens may demonstrate clinal variation between northern and southern populations.

TABLE 1. Frequency distributions of trunk, tail and total rings in species of *Lissocampus*.

Character	Species				
	<i>caudalis</i>	<i>fatiloquus</i>	<i>filum</i>	<i>runa</i>	<i>bannwarthi</i>
Trunk rings					
12	1*				
13	6	6*	1	23*	
14	1		39*	2	
15			6		
17					11*
Tail rings					
33					4
34					6*
35					1
44		1	1		
45		1*	12	4	
46		3	14	13	
47		1	16	6*	
48			3*	1	
49				1	
51	1				
52	1				
54	3				
55	1				
59	1*				
60	1				
Total rings					
50					4
51					6*
52					1
57		1			
58		1*	2	4	
59		3	11	11	
60		1	10	8*	
61			18	1	
62			5*	1	
64	1				
65	1				
67	3				
68	1				
71	1*				
74	1				

* Primary type.

TABLE 2. Frequency distributions of dorsal and pectoral-fin rays and paired (equivalent) pectoral ray counts in species of *Lissocampus*.

Character	Species				
	<i>caudalis</i>	<i>fatiloquus</i>	<i>filum</i>	<i>runa</i>	<i>bannwarthi</i>
Dorsal-fin rays					
13	5*			1	
14	3	6*	47*	27	
15			1	2*	
18					10*
19					1
Pectoral-fin rays					
5	11				
6	5*		7	17	
7		11*	67	38*	
8		1	6*		
11					2
12					16*
13					3
Paired pectoral counts					
5	5				
6	2*		1	5	
7		5*	28	15*	
8			1*		
12					5*

* Primary type.

Distribution: *Lissocampus caudalis* has been reported only from Australia and Tasmania. Scott (1961) noted collections from kelp and other material has come from "rock pools" (USNM 216291) and *Zostera* (QVM 1972/5/714).

Material examined: Eight specimens, 68–100 mm SL, including holotype and paratype. Holotype: SAM F.701 (95 mm SL, female), near Kangaroo Is., South Australia, 2 Oct. 1901, M. Rumball. Paratype: SAM F.702 (100 mm SL, female), data as for holotype. Other material: TASMANIA. GCRL 14765, (1). QVM 1972/5/714, (4). USNM 216291, (1).

Lissocampus fatiloquus (Whitley)

Figure 2

Ichthyocampus filum Günther, 1870:170 (in part, Freycinet's Harbor).
Campichthys fatiloquus Whitley, 1943:176, fig. 7 (Shark's Bay, Western Australia).

TABLE 3. Frequency distributions of trunk, tail and total subdorsal rings in species of *Lissocampus*.

Character	Species				
	<i>caudalis</i>	<i>fatiloquus</i>	<i>filum</i>	<i>runa</i>	<i>bannwarthi</i>
Trunk rings covered					
2.50			10		
2.25			8	4	1
2.00		1	25	17*	4
1.75		3	4*	8	4
1.50		1*		1	2*
1.25	1	1			
1.00	3				
0.75	3*				
0.50	1				
Tail rings covered					
0.50			5	10	
0.75			5	8	
1.00		1	17	11*	
1.25	3	2*	8	1	
1.50	4*	1	12*		
1.75	1	2			2
2.00					2
2.25					7*
Total subdorsal rings					
2.25	6*			1	
2.50	2			9	
2.75		1	2	12	
3.00		4*	14	8*	
3.25		1	19*		
3.50			12		
3.75					4*
4.00					4
4.25					3

* Primary type.

Larvicampus fatiloquus, Whitley and Allan, 1958:60 (new combination).
Ichthyocampus fatiloquus, Munro, 1958:88, fig. 608 (new combination).

Diagnosis: Profile of snout essentially straight dorsad; margin of median dorsal snout ridge slightly below or in line with dorsal margin of orbit; total rings 57–60; pectoral-fin rays modally 7.

Description: Dorsal-fin rays 14; rings $13 + 44-47 = 57-60$; subdorsal

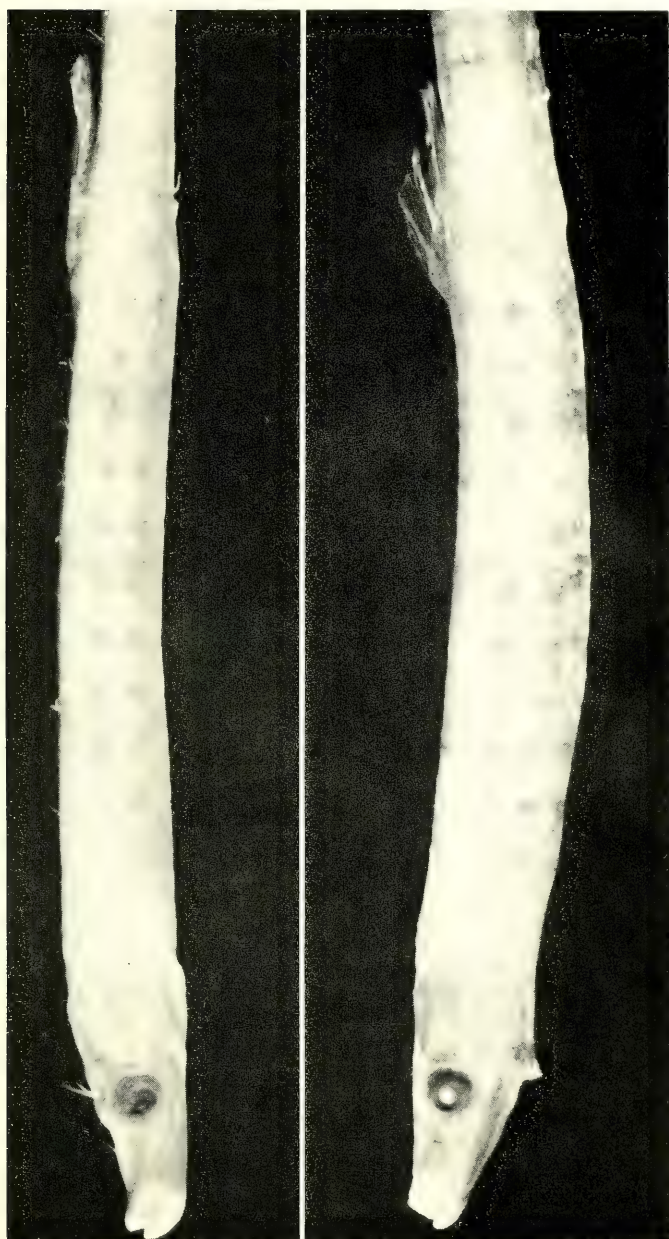


FIG. 2. Head and anterior body of *Lissocampus fatiloquus*. Top: AMS IB.340; 62 mm SL, holotype. Bottom: AMS IB.341; 74 mm SL, male.

rings $1.25-2.00 + 1.00-1.75 = 2.75-3.25$; pectoral-fin rays 7-8, modally 7; see Tables 1-3 for additional counts. Proportional data based on 6 specimens 62-79 ($\bar{x} = 70.7$) mm SL follow: HL in SL 11.8-13.4 (12.65); snout depth in snout length 1.2-1.9 (1.57); length of dorsal-fin base in HL 1.8-2.0 (1.90); anal ring depth in HL 3.3-3.7; pectoral-fin length in HL 3.7-4.5 (last two proportions each based on 3 fish).

Cape approaches angle of 70° in holotype, subvertical in other material; dorsum of head straight to slightly elevated behind eye, without crest or ridges; opercle without ridge but lined with minute radiating striae; pectoral-fin base 2-3 in pectoral-fin length. Dermal flaps slender, simple in all material examined. Holotype with long flaps on snout ridge and dorsal rim of orbit, circlet of minute flaps on eye, flap on mid-dorsum above middle of opercle, another laterad above posterior third of opercle and a short flap anteriad near midline of opercle. Flaps present on superior ridges of most rings and on lateral ridge of most trunk rings; some flaps occur on side of tail and, less frequently, on inferior tail ridges.

Anal-fin rays 3 in holotype and two others examined. Brood pouch below 13 and 16 tail rings in two 74 mm SL males; both without eggs and pouch folds little developed.

Study material faded; traces of brown bar or blotch persist on anterior third of dorsal fin in all specimens. The holotype and AMS IB.341 (Fig. 2) retain paired brownish spots on lateral and inferior ridges of most trunk rings; other markings best preserved in the latter specimen and appear as a series of about 20 ill-defined brownish bands between head and caudal fin, dorsum rather pale and markings best seen on venter and lower part of sides.

Comparisons: The straight and relatively high snout ridge separates *L. fatiloquus* from all congeners except *L. caudalis*. It is separated from this species by higher modal counts of pectoral-fin rays (7 against 5 in *caudalis*) and by lower tail ring counts (44-47 against 51-60 in *caudalis*). These are very similar forms and differences in tail ring counts could well be ascribed to clinal variation between northern and southern populations. Modal pectoral-fin ray counts and frequency of equivalent paired (left and right) pectoral counts (Table 2) are conservative characters in many pipefishes (Dawson and Randall, 1975; Dawson, in press) and I consider differences observed here to support separate status for *L. fatiloquus*.

Remarks: I have examined the type-material of *Lissocampus affinis* (= *L. runa*, q.v.) Whitley (1944) and find the single paratype (AMS IB.341, 74 mm SL, male) to be conspecific with *L. fatiloquus*. This specimen was also dredged by Whitley in Shark's Bay during 1939 and may have been collected with the holotype of *L. fatiloquus*.

Günther (1870) recorded two males from Freycinet's Harbor among his syntypes of *Ichthyocampus filum* and Whitley (1943) speculated that these were most likely specimens of *Lissocampus fatiloquus*. The BMNH collection contains a male and female in an uncataloged lot, without

locality data, originally identified as *Ichthyocampus filum*. I find these specimens to be *Lissocampus fatiloquus* and A. C. Wheeler (BMNH) advises that they must be Günther's Freycinet Harbor material.

This species is, with certainty, known only from Western Australia. Two specimens were dredged, collection data lacking for other material.

Material examined: Six specimens, 62–79 mm SL, including holotype. Holotype: AMS IB.340 (62 mm SL), Western Australia, Shark's Bay, dredged on pearling grounds, 1939, G. P. Whitley. Other material: WESTERN AUSTRALIA. AMS IB.341, (1), paratype of *L. affinis*. WAM uncat., (2). Loc. uncertain: BMNH uncat., (2, presumably the Freycinet Harbor syntypes of *Ichthyocampus filum*).

Lissocampus filum (Günther)

Figure 3

Ichthyocampus filum Günther, 1870:178 (in part; Bay of Islands).

Diagnosis: Profile of snout distinctly concave dorsad; margin of median dorsal snout ridge well below dorsal margin of orbit; trunk rings modally 14.

Description: Dorsal-fin rays 14–15; rings $13-15 + 44-48 = 58-62$; subdorsal rings $1.75-2.50 + 0.50-1.50 = 2.75-3.50$; pectoral-fin rays 6–8, modally 7; see Tables 1–3 for additional counts. Proportional data based on 32 specimens 62.5–107 ($\bar{x} = 88.6$) mm SL follow: HL in SL 11.8–14.4 (13.36); snout length in HL 3.2–4.0 (3.48); snout depth in snout length 1.3–2.0 (1.54), in 19 specimens; length of dorsal-fin base in HL 1.4–1.9 (1.62); anal ring depth in HL 2.4–3.6 (2.91), in 17 specimens; pectoral-fin length in HL 3.8–5.0 (4.4), in 15 specimens.

Gape approximates angle of 70° in most material, occasionally subvertical; median dorsal snout ridge low throughout; dorsum of head elevated behind eye, low fleshy nuchal and prenuchal ridges usually present; opercle with low radiating striae, occasionally with vestigial longitudinal ridge anteriad; pectoral-fin base 2–3 in pectoral-fin length. Dermal flaps slender, short and usually simple, often indicated only by residual pimplelike bases. Flaps may be located as follows: a circlet on eye; flap on snout ridge before eye, one on dorsal margin of orbit and 2–3 behind on middorsum of head; 3 flaps laterad above opercle, 3–5 on fleshy posterior margin of opercle and a median flap on anterior third of opercle; superior, inferior and lateral body ridges with flaps on each ring; flaps often present on tail ridges, midlaterally on tail and on brood pouch folds.

Anal-fin rays 3 in 19 of 22 specimens, 4 in remainder. Brood pouch below 13–16 tail rings in 15 examined males 71–107 mm SL; a 96 mm fish (GCRL 14826) had 86 eggs in pouch.

Dorsal fin with brown blotch or bar anteriad, the rays elsewhere plain or flecked with brown; caudal and pectoral fins plain or flecked with brown, caudal base and proximal third of fin brownish in pale material. Body coloration variably light tan to dark brown (Fig. 3), markings brown.

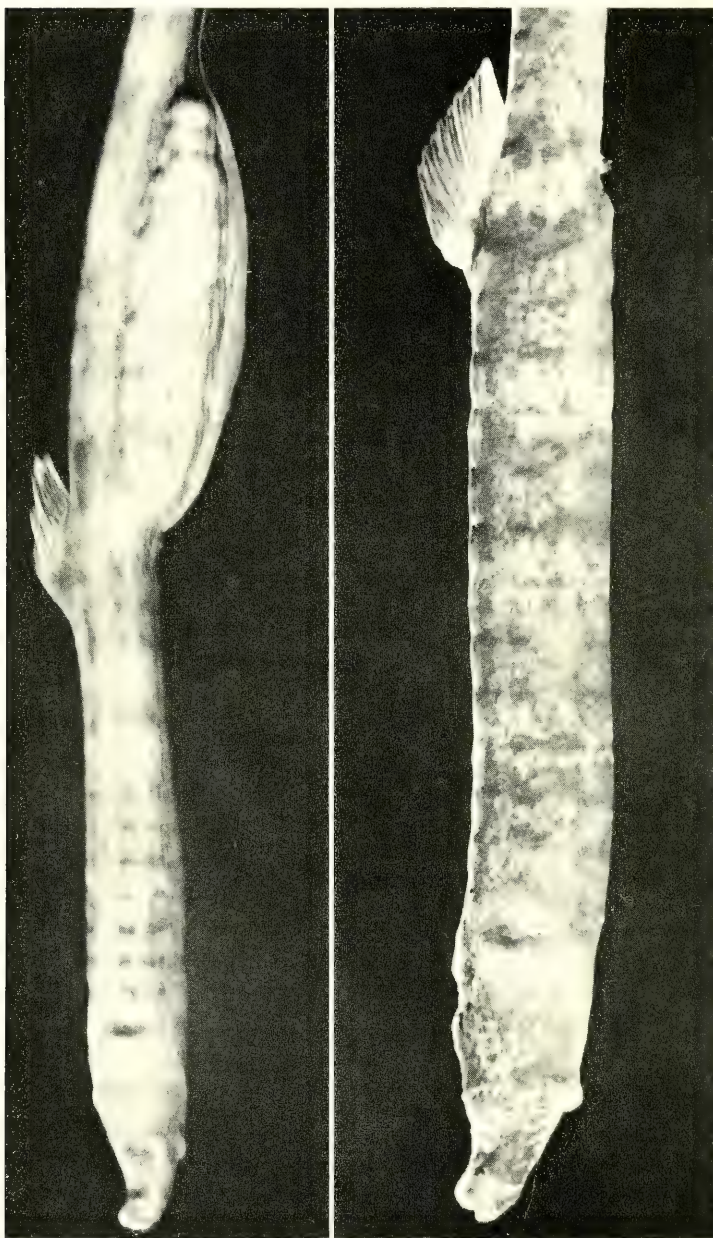


FIG. 3. Head and anterior body of *Lissocampus filum*. Top: GCRL 14827; 93 mm SL, male. Bottom: GCRL 14826; 92 mm SL, female.

Tan material usually with irregular light brown shading on sides and venter of head; venter and lower half of trunk brownish, often with indications of narrow bars, markings darker anteriorly becoming obsolete behind; dorsum crossed by traces of 10–12 irregularly spaced, indistinct brownish bars, subequal to ring length, which may continue a short distance ventrad on sides; brood-pouch folds with indications of 3 widely spaced narrow bars; body elsewhere irregularly and faintly flecked or spotted with brown. Dark specimens with diffuse dark brown bands separated by narrower brown interspaces, dorsum somewhat lighter than sides and venter; some fish with a few pale spots near pectoral-fin base and along lower side of trunk; males often with irregular narrow brown longitudinal lines or streaks on trunk and brood-pouch folds. None of examined material with contrasting sequence of dark brown and white or pale bars.

Comparisons: Among species with 13–15 trunk rings, *L. filum* is readily separated from *L. caudalis* and *L. fatiloquus* by the low snout ridge and concave profile of snout (ridge high, profile straight in *caudalis* and *fatiloquus*). This species is closely related to *L. runa* but differs in modal trunk ring counts (14 against 13 in *runa*) and higher average number of subdorsal rings (3.2 against 2.7). I have not seen specimens of *L. filum* with prominently contrasting bands of brown and white, whereas this color pattern occurs in some specimens of *L. runa*.

Remarks: Günther's (1870) description was based on specimens from Australia and New Zealand. Whitley (1931) assumed that two species were included in Günther's material and restricted the type-locality of *Ichthyocampus filum* to the Bay of Islands, New Zealand (see under *fatiloquus* for discussion of Australian syntypes).

I have examined the Bay of Islands syntypes (BMNH uncat.) and select the mature male (ca. 91.5 mm SL) as the lectotype of *Ichthyocampus filum*. This specimen is brittle and somewhat distorted but the following measurements (mm) were obtained: HL 7.1, snout length 2.1, snout depth 1.3, length of dorsal-fin base 3.4. The pectoral fins are somewhat damaged but there appear to be 8 rays in each; see Tables 1–3 for other counts. Eight eggs remain in the pouch, no dermal flaps persist and the specimen is faded except for traces of a brown blotch anteriorly on dorsal fin.

One specimen examined (NMNZ 25646) is from Port Pegasus, Stewart Is., off the southern tip of South Island, New Zealand; remaining material was collected from Cook Strait north to Cavalli Is. off North Island, N.Z. and from the Chatham Is. Dr. J. Moreland (NMNZ) advises that this species occurs along both east and west coasts of South Island, New Zealand. Depth records for four lots range from "sublittoral" to 6.1 m; one collection (NMNZ 6915) is from a rockpool.

Material examined: Fifty-one specimens, 35–107 mm SL, including lectotype and two paralectotypes. Lectotype: BMNH uncat. (ca. 91.5 mm SL, male), New Zealand, Bay of Islands, Sir G. Gray, donor. Paralectotypes: BMNH uncat. (2 females; one ca. 82.5, other damaged), data

as for lectotype. Other material: NEW ZEALAND. ANSP 119329, (2); 119330, (1); 119331, (2). BMNH 1886.11.19.101, (1). CAS 15154, (1). GCRL 14826, (2); 14827, (3). HJ uncat., (2). NMNZ 1309, (5); 3134, (1); 3223, (1); 3250, (2); 3427, (3); 4096, (2); 5646, (1); 6583, (4); 6584, (11). USNM 216302, (2). CHATHAM Is., KAINGAROA. NMNZ 6915, (2).

Lissocampus runa (Whitley)

Figure 4

Ichthyocampus filum (non Günther, 1870), McCulloch, 1909:318, pl. 90, fig. 1 (Sydney, New South Wales).

Festucalex (*Campichthys*) *runa* Whitley, 1931:313 (new name for McCulloch's material).

Lissocampus affinis Whitley, 1944:266 (Rottnest Is., Western Australia).

Larvicampus runa Whitley, 1948:75 (type-species of *Larvicampus* Whitley, 1948).

Festucalex runa, Herald, 1953:236 (as junior synonym of *Ichthyocampus filum* Günther).

Ichthyocampus runa, Munro, 1958:88, fig. 609 (new combination).

Diagnosis: Profile of snout distinctly concave dorsad; margin of median dorsal snout ridge well below dorsal margin of orbit; trunk rings modally 13.

Description: Dorsal-fin rays 13–15; rings 13–14 + 45–49 = 58–62; subdorsal rings 1.5–2.25 + 0.5–1.25 = 2.25–3.0; pectoral-fin rays 6–7, modally 7; see Tables 1–3 for additional counts. Proportional data based on 19 specimens 63.5–92 (\bar{x} = 77.7) mm SL follow: HL in SL 11.6–13.9 (12.76); snout length in HL 2.8–3.4 (3.20); snout depth in snout length 1.2–2.0 (1.50), in 12 specimens; length of dorsal-fin base in HL 1.8–2.3 (2.00); anal ring depth in HL 2.2–3.8 (3.05), 8 fish; pectoral-fin length in HL 4.7–6.0 in 4 fish.

Gape usually subvertical; median dorsal snout ridge low; profile of head elevated behind eye, often with indications of low fleshy nuchal and prenuchal ridges; operculum with indistinct radiating striae, infrequently with vestigial ridge anteriad; pectoral-fin base 2–3 in pectoral-fin length. Dermal flaps typically simple in examined material, often indicated only by low pimplelike projections and similar projections may be scattered irregularly over much of body (Fig. 5). Flaps located bilaterally on side of snout behind gape, distribution otherwise similar to that described for *L. filum*.

Anal-fin rays 3 in 16 of 17 specimens, 4 in remainder. Brood pouch below 12–14 tail rings in 11 males 69–86 mm SL; an immature 75 mm specimen had pouch folds below 8 tail rings.

Dorsal fin with indication of brown blotch or bar in front, fin elsewhere mainly pale but some fish with rays lightly flecked with brown; pectoral and caudal fins unusually pale. Most material obviously faded but body coloration variably tan to dark brown, markings brown. Tan

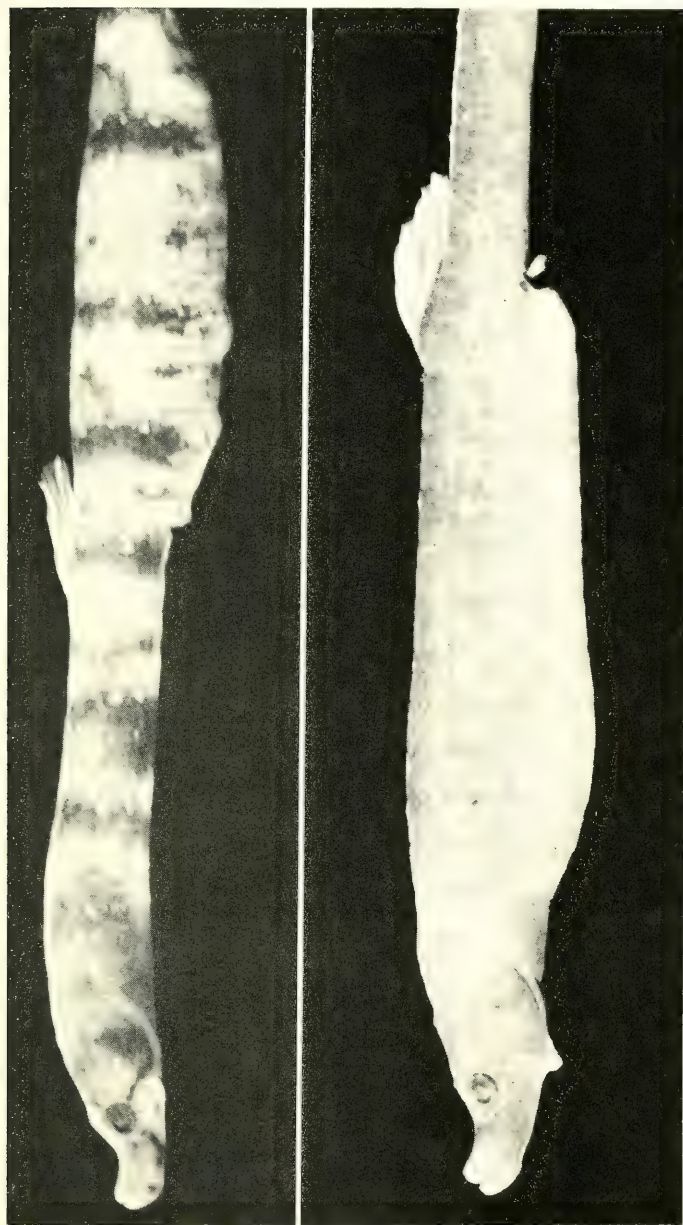


FIG. 4. Head and anterior body of *Lissocampus ruma*. Top: USNM 216290; 78 mm SL, male. Bottom: AMS I13719; 92 mm SL, female.

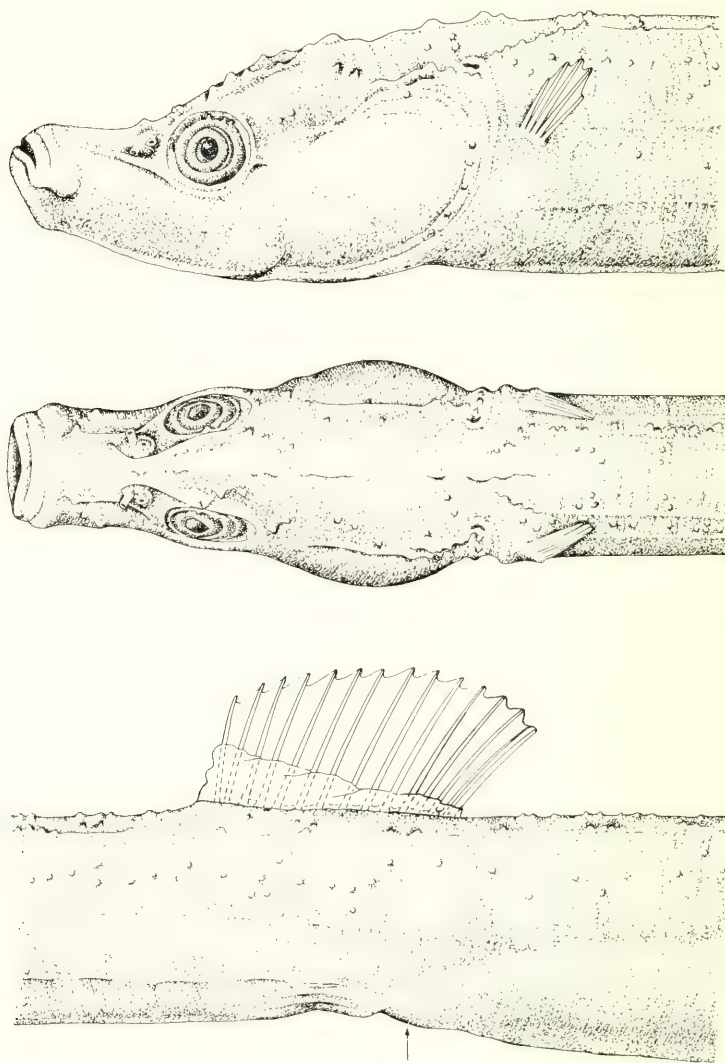


FIG. 5. *Lissocampus runa* AMS I.9020, lectotype. Top and middle: Lateral and dorsal aspects of head and anterior trunk rings; indicated head ridges fleshy. Bottom: Section of body illustrating ridges, elevated dorsal-fin base, modified dorsal-fin membrane and pimplelike projections; arrow indicates approximate position of anal fin within brood-pouch folds. Some flaps omitted.

specimens with irregularly brownish shading on head; lower portion of sides and venter of trunk somewhat brownish, often with traces of narrow dark bars; dorsum with indications of broad bars (2–3 rings long), body elsewhere lightly and irregularly flecked or spotted with brown. Dark specimens with posterior third of opercle pale and indications of dark bars on body; occasionally with minute pale spots near pectoral-fin base and on bases of dermal flaps. Several males distinctly banded with brown and white (Fig. 4); 4–5 bands on trunk, 12–16 on tail and with 4–6 bands crossing brood-pouch folds.

Comparisons: *Lissocampus runa* is closely related to *L. filum* and differs mainly in having a lower modal trunk ring count (13 against 14 in *filum*) and a lower average number of subdorsal rings (2.7 against 3.2). The brood pouch of *L. runa* usually (83%) extends below 12–13 tail rings whereas the brood pouch includes 14–16 rings in 93% of examined *L. filum*. The contrasting banded coloration of some *L. runa* (Fig. 4) did not occur in examined *L. filum*, but fresh study material was not available for adequate comparisons. Modal trunk ring frequency is a highly conservative character and I consider this difference to be a sufficient basis for separate treatment of these species.

Remarks: The syntypes of *Festucalex* (*Campichthys*) *runa* (AMS I.9020) consist of two specimens and I select the male (82.5 mm SL) as the lectotype. This fish is faded; the last two dorsal-fin rays are approximated rather than more or less equally spaced as in most other specimens; brood pouch extends below 14 tail rings. Measurements (mm) follow: HL 6.2, snout length 2.2, snout depth 1.5, length of dorsal-fin base 3.4, anal ring depth 2.5, pectoral-fin length 1.3, length of pectoral-fin base 0.5.

Whitley (1944) reported the holotype of *Lissocampus affinis* to have 11 dorsal-fin rays, 5 pectoral-fin rays, 9 caudal rays, 12 + 46 rings, no anal fin, and that the dorsal fin was located over the last two body rings. My counts from this specimen follow: dorsal 13, pectoral 6 on each side, caudal 10, rings 13 + 46, anal fin present within brood-pouch folds, subdorsal rings $1.75 + 0.75$. The dorsal fin is evidently anomalous in that there is an exceptionally wide space between the 7th–8th rays, the undamaged membrane suggests that one fin-ray failed to develop. I find no substantial differences in residual coloration or other characters and consider the specimen conspecific with *Lissocampus runa*. The specimen of *L. affinis* (SAM F.3245) reported by Glover (1968) and Scott, *et al.* (1974) is also referred to *L. runa*.

This species is known only from Australia and Tasmania; two collections are reported from “rockpools.”

Material examined: Thirty-one specimens, 44–92 mm SL, including lectotype and paralectotype. Lectotype: AMS I.9020 (82.5 mm SL, male), Australia, New South Wales, Long Bay, Sydney, July 1907, A. R. McCulloch, donor. Paralectotype: AMS I.9020 (63.5 mm SL), data as for lectotype. Other material: WESTERN AUSTRALIA. WAM P.1150 (holotype of *L. affinis*). USNM 216290, (1). SOUTH AUSTRALIA. SAM

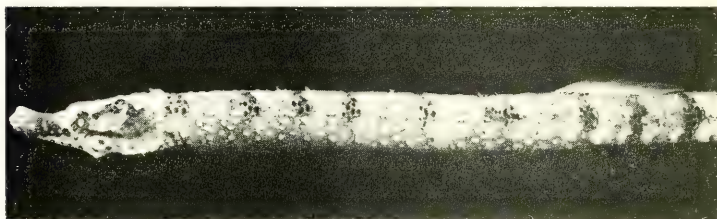


FIG. 6. Head and anterior body of *Lissocampus bannwarthi*. GCRL 14820; 105 mm SL.

F.3245, (1); F.3440, (1). NEW SOUTH WALES. AMS I.9268, (9); I.9956-7, (3); I.13719, (2); IA.6195, (1); IA.1243, (2). CAS 36585, (1). USNM 84381, (3); 88269, (1). TASMANIA. AMS I.17543-001, (1). QVM 1976/5/93, 1976/5/131, 1976/5/142.

Lissocampus bannwarthi (Duncker)

Figure 6

Ichthyocampus bannwarthi Duncker, 1915:93 (Suez).

Diagnosis: Profile of snout broadly concave dorsad; margin of median snout ridge below dorsal margin of orbit; total rings 50-52; pectoral-fin rays 11-13.

Description: Dorsal-fin rays 18-19; rings $17 + 33-35 = 50-52$; sub-dorsal rings $1.5-2.25 + 1.75-2.25 = 3.75-4.25$; pectoral-fin rays 11-13, modally 12; see Tables 1-3 for additional counts. Proportional data on 11 specimens 101-132 ($\bar{x} = 109.8$) mm SL follow: HL in SL 10.8-11.9 (11.34); snout length in HL 2.6-2.8 (2.69); snout depth in snout length 2.5-2.9 (2.75); length of dorsal-fin base in HL 1.3-1.5 (1.41); anal ring depth in HL 2.6-3.4 (3.03); pectoral-fin length in HL 3.9-5.2 (4.64).

Gape subvertical; median dorsal snout ridge (Fig. 7) low but angled somewhat dorsad before eyes; dorsum of head elevated, rounded and without ridges; operculum waffled with minute intersecting low striae, usually with vestigial ridge anteriad; dorsal-fin base elevated anteriad; dorsal-fin membrane usually somewhat swollen or enlarged about anterior 4-5 fin rays; pectoral-fin base 1.4-1.8 in pectoral-fin length. Dermal flaps well developed, usually branched or frilled on head and trunk but frequently simple on posterior third of tail; midlateral flaps often present on tail rings. Anal-fin rays 4 in 7 of 11 specimens, 3 in remainder.

Dorsal fin with brownish blotch on membrane anteriad; dorsal, anal and pectoral-fin rays faintly margined with brown; caudal fin with light brown shading. Sides and dorsum of head irregularly shaded with brown over light tan ground color, usually with irregular patch of several dark brown ocellated spots dorsolaterad behind eye, often with similar patch

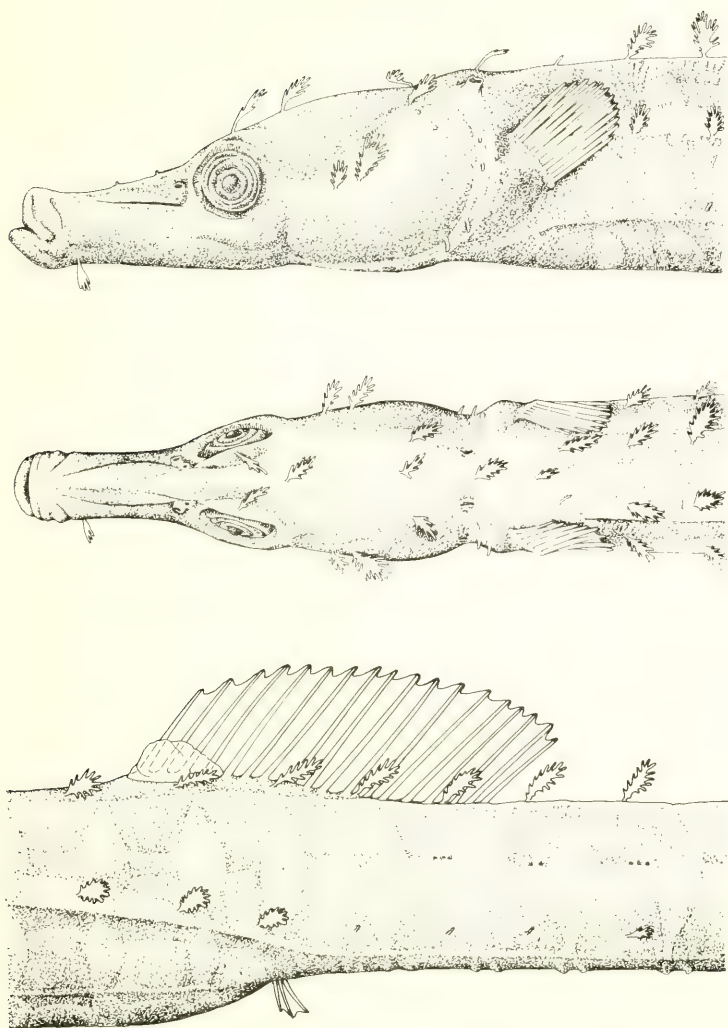


FIG. 7. *Lissocampus bannwarthi* USNM 216292, neotype. Top and middle: Lateral and dorsal aspects of head and anterior trunk rings. Bottom: Section of body illustrating ridges, dermal flaps, dorsal and anal fins.

on interorbital; venter of head pale with irregular scattering of medium brown spots or blotches. Sides and dorsum of body with indications of about 20 irregular, diffuse, dark bands (Fig. 6), most distinct on upper part of sides and each usually includes an irregular patch of ocellate dark spots; trunk with venter and lower part of sides medium brown, sides often with irregular tan spots ventrad; venter of tail brown or more frequently, with irregular series of barlike blotches. Color description from recently collected material (BPBM 19832, GCRL 14820).

Comparisons: *Lissocampus bannwarthi* is readily separable by characters in the key and other meristic differences (Tables 1–3). This species further differs from known congeners in having a less extensive modification of the dorsal-fin membrane and in the modal count of 4 rather than 3 anal-fin rays.

Remarks: Mature males were not available and information is lacking on brood-pouch eggs or type of pouch closure. Duncker (1915) stated that pouch protective plates were absent and that the brood-pouch extended below 17–18 tail rings.

Duncker's type-material, deposited in the Hamburg Museum, was destroyed during World War II. I therefore select USNM 216292 (Fig. 7) as the neotype of *Ichthyocampus bannwarthi*. Measurements (mm) of this 122.5 mm SL specimen follow: HL 10.6, snout length 4.0, snout depth 1.4, length of dorsal-fin base 7.2, anal ring depth 4.0, pectoral-fin length 2.7, length of pectoral-fin base 1.6; see Tables 1–3 for counts.

This species, listed as a possible Red Sea endemic by Botros (1971), has been illustrated previously by Hora (1925, pl. 10, fig. 3) but it has seldom been recorded in literature and there are few specimens in collections. This is somewhat surprising, since present material was taken in depths of 0–2.4 m. Previous records are as follows: Suez (Duncker, 1915), Sinai Peninsula (Hora, 1925), Ghardaqa (Duncker, 1940).

Material examined: Eleven specimens, 101–132 mm SL, including neotype. Neotype: USNM 216292 (122.5 mm SL, presumably female), Red Sea, 27°16'46"N, 33°46'25"E, 0–2.4 m, 1 Jan. 1965, L. Kornicker and H. A. Fehlmann. Other material: RED SEA. BPBM 19832, (8), GCRL 14210, (2), Gulf of Aqaba, NW shore, El Muzeini, N of Nuweiba, sand and small rocks, 0–0.5 m, 31 Oct. 1975, J. E. Randall and J. Vendling.

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PROCEEDINGS
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A NEW GENUS AND EASTERN PACIFIC SPECIES
OF BODIANINE LABRID FISH

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Gomon and Randall (1975) published an abbreviated description¹ of a new labrid species, *Bodianus russelli*, allocated to *Bodianus* on the basis of preliminary results of an ongoing revision of the tribe Bodianini (subfamily Bodianinae of Norman, 1966). The revision currently being undertaken by Gomon indicates that several characters (including jaw dentition, extent of squamation and scale counts) used to distinguish various genera closely allied to *Bodianus* (= *Lepidaplois*) are unsatisfactory. Gomon and Randall interpreted the meristic and morphological characters of *russelli* to be within the realm of interspecific variation of *Bodianus*. Subsequent osteological analyses, however, indicate that *russelli* lacks a number of specializations shared by the other species of *Bodianus*, and merits generic recognition. A thorough discussion of the osteology and phylogenetic relationships of the tribe Bodianini will be presented in a forthcoming paper. In addition, recent collecting in the tropical Eastern Pacific has revealed a second species closely related to *russelli* that also belongs to the genus described here. A description of this second species follows that of the genus.

¹ A comprehensive description of *russelli* will appear in: Gomon and Randall (in press). A review of the Hawaiian labrid fishes of the tribe Bodianini, Bulletin of Marine Science.

METHODS

Type specimens are deposited in fish collections of the following institutions: California Academy of Sciences (CAS); Scripps Institution of Oceanography, University of California (SIO); University of Costa Rica (UCR); Rosenstiel School of Marine and Atmospheric Science, University of Miami (UMML); U. S. National Museum of Natural History (USNM).

Terminology follows that of Hubbs and Lagler (1947) except: caudal-fin ray count includes dorsal unsegmented rays + dorsal segmented, unbranched rays + segmented, branched rays + ventral segmented, unbranched rays + ventral unsegmented rays; pectoral fin rays are indicated with unbranched rays in lower case Roman numerals and branched rays in Arabic (the dorsalmost pectoral-fin ray in labrids is typically short, unsegmented and unbranched; the second ray is typically long, segmented and unbranched); gill-raker counts are given as upper and lower-limb counts and include all rudiments (raker at angle included in lower-limb count); orbital length is the horizontal measurement. Figures enclosed by parentheses following meristic data indicate number of specimens or structures (e.g., pectoral fins, lateral lines) exhibiting count, unless stated otherwise; when meristic ranges are given, the count for the holotype is indicated by an asterisk (*). Measurements were taken in mm with needlepoint dial calipers; morphometric dimensions are given as ranges in percent of standard length (SL).

Polylepion, new genus

Type-species: *Bodianus russelli* Gomon and Randall 1975.

Diagnosis: Labrid fishes with the following combination of characters: dorsal fin XI, 11; anal fin III, 11–12; pectoral fin ii, 17–19 (usually 18); lateral-line scales 48–52 (usually 50); scales above lateral line 2½–5; scales below lateral line 16–19 (usually 17 or 18); predorsal scales approximately 25–32, reaching in front of anterior nostril or at least to anterior edge of orbit; color in alcohol pale except for dusky to dark spot on dorsal fleshy base of caudal fin, and dark interradiat membranes anteriorly in dorsal fin of one species.

Etymology: *Polylepion*, derived from the Greek adjective *polys* (many) and neuter noun *lepion* (small scales), refers to the relatively numerous lateral-line scales occurring in species of this genus.

TABLE 1. Comparison of selected characters between *Polylepion* and four closely related genera; figures in parentheses indicate infrequently occurring meristic values.

Genus	Dorsal fin	Anal fin	Pectoral fin	Vertebrae	Lateral line scales	Base of dorsal and anal fin	Squamation of head dorsum
<i>Polylepion</i>	XI, 11	III, 11-12	ii, 18 (17, 19)	11 + 17	48-52	Naked	Scales reaching forward to anterior edge of orbit or in advance of anterior nostril
<i>Bodianus</i>	XII, 10 (9, 11)	III, 12 (11)	ii, 14-15 (16)	11 + 17	30-48	Naked or scaled	Scales approaching posterior edge of orbit, reaching in advance of anterior nostril or reaching anywhere between
<i>Decodon</i>	XI, 10 (9)	III, 10	ii, 14-15	11 + 17	26-30	Naked	Scales reaching forward to about anterior nostril
<i>Pimelometopon</i>	XII, 10	III, 12	ii, 16 (15, 17)	11 + 17	53-57	Naked	Scales reaching forward to about posterior extent of orbit
<i>Semicossyphus</i>	XII, 10	III, 12	ii, 15	12 + 16	42-45	Naked	Scales reaching forward to about posterior extent of orbit

Comparisons: Species of *Polylepion* most closely resemble the bodianine genera *Decodon*, *Pimelometopon*, *Semicossyphus* and *Bodianus*, especially those species that lack scales on the basal portion of the dorsal and anal fins. A comparison of selected meristic and morphological characters of these five genera appears in Table 1. Certain osteological features including the nature of the association of the frontals and medial ethmoid and the structure of the posterior ends of the lower jaw bones indicate that ancestors of the genus *Polylepion* diverged early from the line giving rise to *Bodianus*.

The genus contains two species, *russelli*, from the Hawaiian and Ryukyu Islands, and *cruentum* described below from the western coast of Central America.

***Polylepion cruentum*, new species**

Figures 1, 2 left, 3

Holotype: USNM 215465 (110), Eastern Pacific, Costa Rica, off Quepos, depth 190 m, shrimp trawl, collected by Frederick H. Berry, 11 March 1974.

Paratypes: USNM 215466 (10, 64.1–107), same data as holotype, 1 specimen cleared and stained; CAS 36000 (2, 118–92.0), same data as holotype; UMML 32923 (3, 56.8–74.3), same data as holotype except depth 165 m; SIO 68-4-50 (199), Mexico, Baja California Sur, San Jaime Bank, 22°53.9'N, 110°15.8'W, G. Moser, 11 December 1967; UCR 353-2 (139), Eastern Pacific, Costa Rica, Puntarenas, 5 mi. SE Cabo Blanco, depth 154 m, try net, R. T. Nishimoto, 18 July 1969.

Description: (see Table 2 for proportional measurements); Dorsal fin rays XI, 11; anal fin rays III, 12; caudal fin rays 9*(4), 10(5) or 11(2) + 2 + 12 + 2 + 9(8), 10*(2) or 11(1); pectoral fin rays ii, 17(3), ii, 18*(29) or ii, 19(2); pelvic fin rays I, 5; vertebrae 11 + 17; lateral line scales 49(1), 50*(11) or 51(3) + 2(6) or 3*(5) = 52(3) or 53(8), scales above lateral line $2\frac{1}{2}$ – $4\frac{1}{2}$ (usually $3\frac{1}{2}$ *); scales below lateral line 16–18* (usually 17); predorsal scales approximately 25–32 (averaging about 28, 31 in holotype); gill rakers 5–8 + 10–12 = 15–19 (usually 6* or 7 + 11*).

Body moderately narrow, tapering markedly posteriorly. Head large pointed; predorsal profile straight except for convexity above eyes in small specimens; nape nearly straight in juveniles to moderately arched in adults.

Scales on trunk moderately large; scales not extending onto bases of dorsal and anal fins; lateral line smoothly curved, uninterrupted; lateral line scales notched posteriorly, with canal tapered and turned slightly dorsally near posterior edge. Head mostly scaled (Figure 2 left); scales on nape and top of head becoming progressively smaller anteriorly, reaching forward to about midpoint between anterior nostril and snout tip; small scales covering cheek, infraorbital and lower sides of head anteriorly to corner of mouth, somewhat more anteriorly on sides of lower jaw;

TABLE 2. Selected proportional measurements in percent standard length for holotype and paratypes of *Polylepion cruentum*.

Character	Holotype	Paratypes
Standard length (mm)	110	56.8–199
Body depth	27.3	23.5– 29.4
Head length	40.4	38.9– 43.8
Snout length	9.5	7.6– 12.3
Orbital diameter	10.7	8.0– 12.0
Bony interorbital distance	5.6	4.5– 6.0
Upper jaw length	11.1	9.7– 14.2
Predorsal length	36.4	35.7– 38.1
Caudal peduncle depth	13.0	11.8– 13.6
Dorsal-fin base	50.4	46.9– 52.6
Depressed dorsal fin	64.1	59.9– 68.2
First dorsal-fin spine	7.9	7.0– 8.6
Eleventh dorsal-fin spine	10.2	9.1– 12.2
Anal-fin base	22.8	21.8– 25.3
Depressed anal fin	34.2	33.9– 38.2
First anal-fin spine	5.8	4.7– 6.5
Third anal-fin spine	10.3	8.6– 10.9
Upper segmented caudal-fin rays	21.4	19.5– 23.1
Central segmented caudal-fin rays	21.0	20.7– 24.2
Pectoral-fin length	18.2	17.3– 20.6
Pelvic-fin length	20.4	14.7– 25.0

narrow posteroventral margin of preopercle naked; free preopercular margin smooth in adults, posterior edge minutely serrate in juveniles; operculum mostly covered by large scales; posterior opercular membrane naked with large dorsoposterior flap.

Lower lip broad, greatly exposed when mouth closed in largest specimen, much less so in smaller specimens; crease at corner of mouth curved dorsally; posterior end of maxillary reaching below a point about midway between anterior edge of orbit and center of eye. Each jaw (Figure 3) with two pairs of widely spaced, large, curved canines anteriorly; anterior canines in upper jaw of equal size, followed by single row of 6 to 14 (averaging about 9 or 10) much smaller canines and 1 or 2 (usually 1) moderately large canines positioned near posterior tip of jaw; anteromedial canine on each side of lower jaw markedly smaller than second canine, followed by a single row of 8 to 19 smaller canines in two series, an anterior series of usually 7 or 8 teeth and an adjoining posterior row of usually 6 or 7 distinctly smaller teeth. Gill rakers moderately long, raker in angle often bifurcate distally.

Dorsal fin continuous, origin slightly anterior to a vertical at axis of pectoral fin, well in advance of posterior extent of opercular margin;

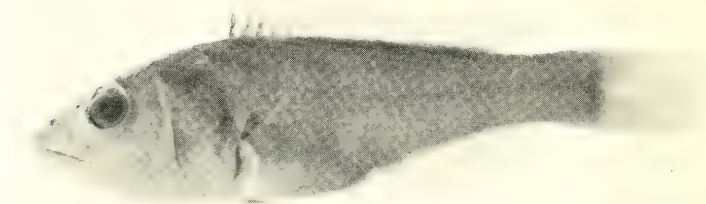


FIG. 1. *Polylepion cruentum*, SIO 68-4-50, paratype, 199 mm SL.

first dorsal fin spine slightly shorter than second (difference greater in smaller specimens), succeeding spines of nearly equal length; membrane between dorsal and anal fin spines deeply incised, flag-like process produced from tip of each spine; dorsal and anal fins slightly pointed posteriorly, distinctly not reaching posterior edge of hypurals in all but juveniles (dorsal fin of specimens smaller than about 70 mm reaching edge). Caudal fin slightly rounded in juveniles to truncate with center of posterior fin edge convex in largest individuals. Pelvic fins short in juveniles, first segmented ray becoming filamentous, reaching beyond anus in larger adults.

This species attains at least 199 mm SL. All type-specimens larger than 97 mm, including the holotype, are males; females range in size from 74.3–94.1 mm; two specimens measuring 56.8 mm and 64.5 mm appear to be immature.

Color in alcohol: Mostly pale; membranes between anterior dorsal fin spines black, dark pigment confined to fin base and fin margin between posterior spines. Juveniles with oval black spot, approximately equal to eye diameter, present on upper fleshy base of caudal fin (centered at posterior edge of hypurals); spot becoming fainter in larger specimens, usually absent in specimens larger than 100 mm. Opercular region appearing dusky from dark pigment on inner side of opercular flaps. Freshly preserved specimens with faint irregular narrow dusky stripes on nape and dorsal portion of body.

Color in life: Mostly pink; chest, belly and underside of head white. Approximately three or four narrow, wavy yellow stripes on dorsal two-thirds of body posterior to head (stripes more numerous in juveniles). Yellow stripes separated by pearly pink stripes in juveniles, with two and then one pink stripe becoming accentuated midlaterally in adults; single stripe reaching from posterodorsal extent of opercular flap to below fourth segmented dorsal fin ray in largest specimen examined. Head with wavy yellow stripes and marks; first stripe broad, directed forward from ante-

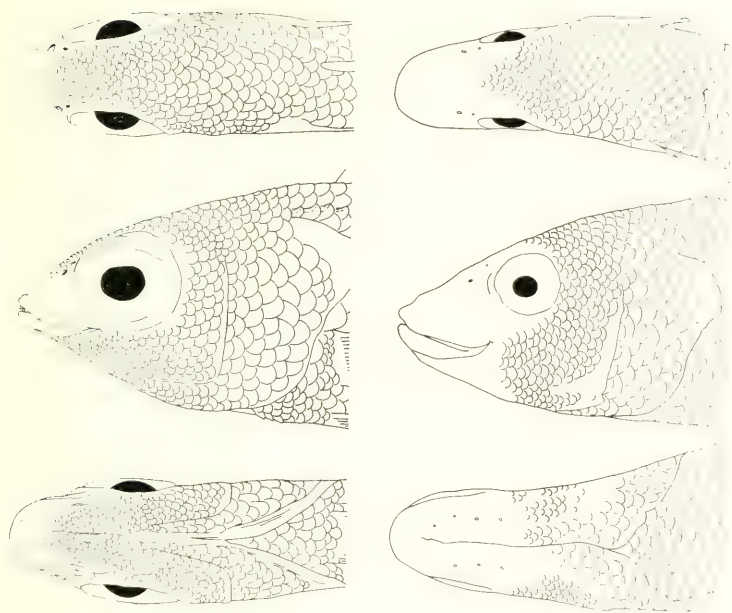


FIG. 2. Scale pattern on head of *P. cruentum* (left), USNM 215466, 75.9 mm SL, and *P. russelli* (right), USNM 212175, 287 mm SL. From top to bottom: dorsal, lateral and ventral views.

rior extent of orbit, connecting with corresponding stripe from opposite side across snout; second stripe forming broad yellow border to entire upper lip, continuing posterodorsally around posteroventral quarter of orbital rim and then directed posterodorsally to upper angle of gill opening; several other short irregular marks on side of head including vertical line or blotch on posterior margin of preopercle and short horizontal line ventrally on cheek below posterior extent of orbit. Narrow black border present on dorsal side of eye. Large oval spot on upper fleshy caudal base black in juveniles, becoming blood red in adults (change in color occurring at about 75 mm), spot becoming diffuse in very large individuals; spot outlined, at least anteriorly, by broad pearly pink border. Dark pigment in spinous portion of dorsal fin black, two anteriorly converging reddish pink stripes present on segmented portion of fin, one basally and one midlaterally; broad distal portion of fin and area between pink stripes yellow. Anal fin white with broad distal yellow stripe. Caudal fin pinkish dorsally and ventrally, separated by broad yellowish expanse; narrow black posterior margin of fin present in some specimens. Pectoral fins transparent with broad blood red band on fleshy base. Pelvic fins white.

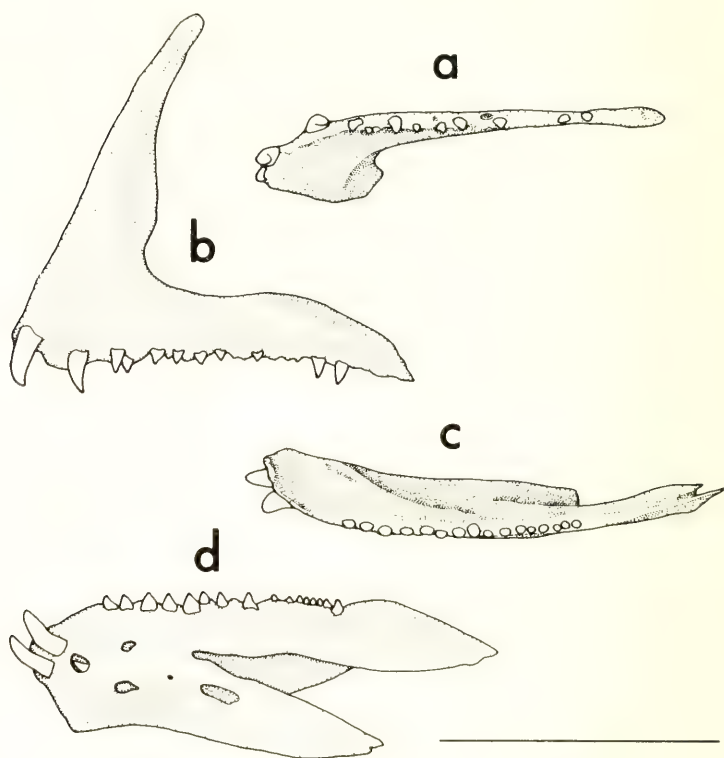


FIG. 3. Dentition in upper and lower jaws of *P. cruentum*. Premaxillary: (a) ventral view, (b) lateral view. Dentary: (c) dorsal view, (d) lateral view. USNM 215466, 79.2 mm SL. Line indicates 5 mm.

Distribution: Type-specimens were collected in two localities, Gulf of California and Pacific coast of Costa Rica, at depths of 150 to 200 m. This species has been taken on several occasions with *Decodon melasma* and with additional collecting undoubtedly will be shown to occur at similar depths in soft bottom areas associated with rock rubble and rock reefs all along the tropical Eastern Pacific coast of the Americas.

Etymology: *cruentum*, a Latin adjective meaning spotted with blood, in reference to the blood red marks on the caudal peduncle and pectoral fin base in live adults.

Relationships: *P. cruentum* differs from *P. russelli* in having III, 12 anal-fin rays (III, 11 in *P. russelli*), scales on forehead extending forward in advance of anterior nostril (only to anterior extent of orbit in *P. russelli*, Figure 2) and anterior interspinal membranes of dorsal fin black

(not darkly pigmented in *P. russelli*), in addition to other differences in life colors. In body proportions, *P. cruentum* has a longer head (38.9–43.8 versus 35.6–37.7), narrower caudal peduncle (11.8–13.6 versus 13.9–15.5) and pelvic fin that reaches a greater length, becoming filamentous in adults (14.7–25.0 versus 14.4–18.8, not filamentous in *P. russelli*). This species may also have a larger eye and orbit (8.0–12.0 versus 6.5–7.2), narrower bony interorbital (4.5–6.0 versus 6.3–8.1) and shorter depressed anal fin (33.9–38.2 versus 28.7–31.7); however, these characters exhibit disproportionate allometric changes and approach values recorded for *P. russelli* in the largest specimens. The smallest specimen of *P. russelli* presently available measures 249 mm SL.

Both species appear to occur at great depths relative to other bodianines and for that matter all labrids. Because rocky areas at these depths are infrequently collected, it might be expected that the ranges of such fishes are much broader than currently recognized.

ACKNOWLEDGMENTS

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PROCEEDINGS
OF THE
BIOLOGICAL SOCIETY OF WASHINGTON

THE TAXONOMIC STATUS OF *SESARMA FESTAE*
NOBILI, 1901, *S. OPHIODERMA* NOBILI, 1901, AND
S. BIOLLEYI RATHBUN, 1906 (CRUSTACEA, DECA-
PODA, GRAPSIDAE) IN THE EASTERN PACIFIC

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There are 38 nominal species of the grapsid crab genus *Sesarma* reported from the Americas. Rathbun (1918) considered 27 of these to be valid although she had not examined material of all species. This report is based on an examination of type material and is a contribution towards a review of the American species of *Sesarma*. It is concluded that *S. festae* and *S. biolleyi* are junior synonyms of *S. occidentale* Smith, 1870 and that *S. ophioderma* is a junior synonym of *S. angustum* Smith, 1870.

Serene and Soh (1970), in a review of some Indo-Pacific Sesarminae, proposed that the genus *Sesarma* be subdivided into a number of smaller genera. With reference to the American fauna this would mean recognition of the subgenera *Sesarma* and *Holometopus* at the generic level. The character they used to separate *Holometopus* and *Sesarma*, however, is variable (Abele, 1975:51). Since their proposal, Hagan (in press) has presented morphological, behavioral and ecological data which suggest that there are at least 2 groups of species among the American *Sesarma* fauna; these correspond to the subgenera *Sesarma* and *Holometopus* and will be recognized as such in the present report.

A series of measurements were taken on the species (Tables 1 and 2) which included a size range of both sexes. The

following abbreviations are used: *cl*, carapace length taken at midline; *cb*, carapace breadth at midlength; *iw*, the width of the frontal region at the distal margin; *aw*, abdominal width measured at the proximal margin of the sixth abdominal segment; *al*, abdomen length measured with the abdomen pressed against the sternum; *rcl*, *rch*, *rcw* and *lcl*, *lch*, *lcw* refer to the length, height and width of the right and left chelae; *ml*, *mw*, the merus length and width; *c*, carpus length; (maximum length along the extensor margin); *p*, propodus length; *ps*, propodal spines that occur on the ventral border and distal margin, e.g., a formula of 10 + 2 indicates 10 pairs (separated) of spines on the ventral border and 2 on the distal border; *d*, dactylus length; *ds*, dactylus spines that occur in two poorly defined rows on the dorsal and ventral borders, e.g., a formula of 4/3 indicates 2 dorsal rows of 4 spines each and 2 ventral rows of 3 spines each. YPMNH refers to the Yale Peabody Museum of Natural History and USNM refers to the National Museum of Natural History, Smithsonian Institution.

Sesarma (Holometopus) occidentale Smith, 1870

Figures 1, 2, 3a-3h

Sesarma occidentalis Smith, 1870: 158 (type-locality Acajutla, El Salvador).

Sesarma (Holometopus) occidentalis: Nobili, 1901: 42.

S. (Holometopus) festae Nobili, 1901: 42 (type-locality Tumaco, Colombia).

Sesarma (Holometopus) biolleyi Rathbun, 1906: 100 (type-locality Salinas de Caldera, Boca del Jesus Maria, Costa Rica).

Sesarma (Holometopus) occidentale: Rathbun, 1918: 299, fig. 148.

Sesarma (Holometopus) biolleyi: Rathbun, 1918: 306, fig. 150, pl. 87, figs. 2, 3.

Sesarma (Holometopus) festae: Rathbun, 1918: 313.

Sesarma (Holometopus) occidentalis: Bott, 1955: 63.

Material examined (Coll. no. refers to specimens listed in Table 1): Ecuador, Esmeraldas; 3 ♀ (Coll. no. 5) (syntypes of *S. festae*), E. Festa coll.; Turin Museum Cr 198.

Colombia, Tumaco; 3 ♂ 4 ♀ (Coll. no. 3) (syntypes of *S. festae*), E. Festa coll.; Turin Museum Cr 91.

Panama, Pacific coast, Naos Island; 4 ♂, 3 ♀ (Coll. no. 2); 10 June 1969; L. G. Abele coll.—Albrook Air Force Base, swamp; 1 ♂ (18 June 1974); 3 ♂, 6 ♀ (Coll. no. 4) (23 August 1972); 3 ♀ (6 December 1968); 2 ♂ (6 May 1969); L. G. Abele coll.—Pearl Islands, Mina Island

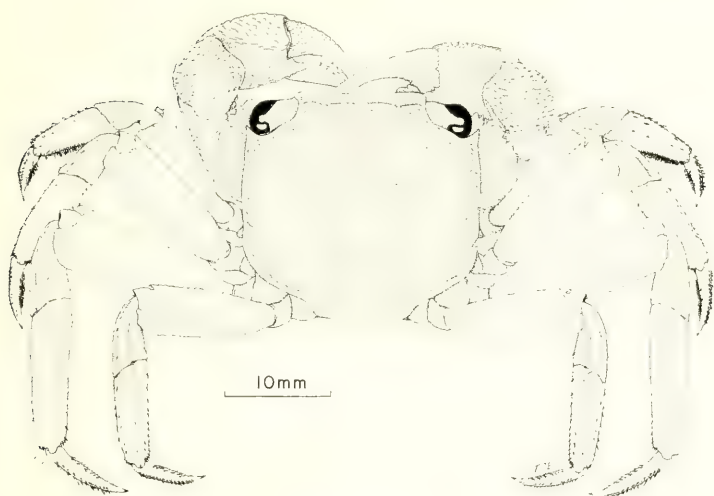


FIG. 1. *Sesarma biolleyi* Rathbun. Holotype male, USNM 32490.

mangrove swamp; 5♂ (Coll. no. 1) 13 June 1973; L. G. Abele coll.—Pearl Islands, Contadora Island mangrove swamp; 2♂, 3♀; 6 January 1973; L. G. Abele coll.—Rio Mar above beach; 1♂ 12 June 1969; L. G. Abele coll.

Costa Rica, Boca del Jesus Maria; 1♂ (holotype of *S. biolleyi*); January, 1906; P. Biolley and J. F. Tristan coll.; USNM 32490.

El Salvador, Acajutla; 2♂ (syntypes of *S. occidentale*); F. H. Bradley coll.; YPMNH.

Description: The carapace is slightly wider than long. The ratio cl/cb is 0.95 ± 0.02 in males and 0.93 ± 0.02 in females. The carapace increases in width posteriorly and there is a very slight emargination posterior to the outer orbital angle. The dorsal surface is covered with a series of low but distinct granules. The interorbital region is subdivided into 4 low lobes. The frontal region widens slightly distally, more apparent in larger specimens. At the widest point the frontal region is about 0.55 of the carapace width. The carapace is not inflated.

The eyes are well developed and pigmented.

The basal segment of the antennula is large, granulated and placed beneath the frontal margin. The basal antennal segment forms a part of the lower orbit as it fits up against a triangular lobe. A groove (Verwey's groove; Hagen, in press) extends from the exhalent opening along the pterygostomial region parallel to the lower orbital margin; a weaker groove runs at an oblique angle from each end of Verwey's groove delimiting a triangular area below the orbit.

The third maxillipeds do not meet and each has an oblique row of pubescence on the segment proximal to the palp.

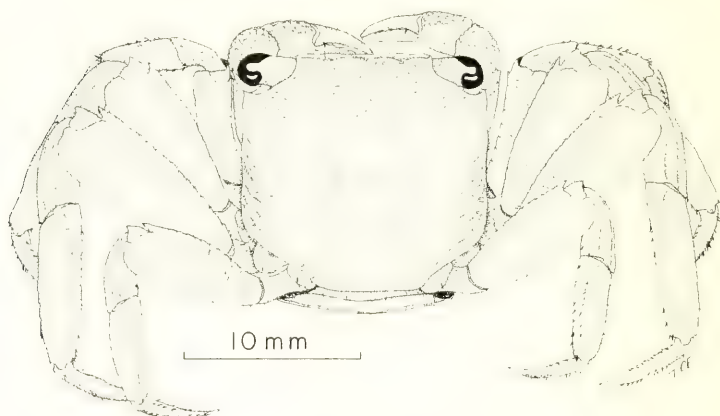


FIG. 2. *Sesarma festae* Nobili. Syntype ovigerous female, Turin Museum 91.

The chelipeds are sexually dimorphic. In both sexes the merus has the medial posterior edge serrated; the anterior edge is expanded with well developed teeth (especially in mature males). The carpus is covered with acute granules, especially along the borders. The chelae of both sexes are covered with acute tubercles; in males the chelae are swollen and there is a large process or protuberance on the medial surface of the palm at the base of the dactylus. The dactylus is broader at its base in males compared to females.

The walking legs are long and relatively slender; they are in order of increasing length: first, fourth, second and third. The ratio of merus length to width varies among the legs and with the size and sex of the animal. For example, the ratio of the fourth leg (fifth pereopod) of small males is about 2.5 while for the third leg of large males it is 3.0. For a series of males (Table 1) the ratio of the third (longest) leg ranged from 2.6 to 3.0; in females it ranged from 2.6 to 2.9. The ratio becomes larger with increasing size in both sexes. In the longest leg (the third), the merus length is slightly less than twice the carpus length; about 1.3 times the propodus length and slightly less than twice the dactylus length. Mature males have a row of thick pubescence along the ventral part of the propodus and dactylus; there is also pubescence along the dorsal part of the propodus but the hairs are more robust. The propodi and dactyli are armed with small, black spines; on the ventral margin of the propodus and on both the ventral and dorsal margins of the dactylus. Some data are presented in Table 1. There are about 5 spines in widely separated pairs along the ventral part of the propodus with 2 more pairs on the distal margin. The spines of the dactylus are in 2 poorly defined rows on the dorsal and ventral surfaces. The number

TABLE 1. Morphological measurements of *Sesarma occidentale* Smith, 1870.

Coll. no.	Fifth Pereopod														Fourth Pereopod														Coll. no.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
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* — ovigerous individual.

and strength of the spines increase with increasing size. The spines are present in females also but are reduced in number compared to males.

The male abdomen is subtriangular in outline; the length and breadth of the telson are subequal. The female abdomen is subcircular in outline.

The male gonopod is simple and unarmed. The endpiece (amber-colored apex) is relatively small and set at an oblique angle to the main axis of the gonopod. The gonopod has a distinct expanded part proximal to the endpiece.

The female gonopore is raised from the sternum and flanked anteriorly and posteriorly by extensions of the sternum; between these is a barbell-shaped process.

Measurements: Males, *cb* 7.3 to 22.0 mm; females, *cb* 7.3 to 15.0 mm; ovigerous females, *cb* 10.1 to 14.8 mm. Males larger than about *cb* 11.0 mm appear to be mature while females appear to attain sexual maturity at about *cb* 10.0 mm.

Type-locality: Acajutla, El Salvador.

Distribution: The species is widely distributed in the eastern Pacific from Esmeraldas, Ecuador to at least Acajutla, El Salvador.

Habitat: *Sesarma occidentale* is semi-terrestrial and occurs in a wide variety of habitats up to 80 m from water. Individuals were collected from under litter along the edge of a brackish water stream, from a dried river bed along the edge of a red mangrove swamp and from among piles of lumber in back of the bunker of the Smithsonian Tropical Research Institute at Naos Island, Panama.

Remarks: Type-materials of *Sesarma occidentale* Smith, 1870, *S. festae* Nobili, 1901 and *S. biolleyi* Rathbun, 1906 were examined and in the author's opinion they are conspecific. Bott (1955) had previously suggested that *S. biolleyi* might be a synonym of *S. occidentale* but he had not examined any type-material. The material of *S. occidentale* consists of 2 males in the YPMNH (PMN 545; *cb* 17.6 and 13.1 mm). Although Rathbun (1918:300) indicated that the larger specimen is a holotype there is no indication of this in the jar. The material of *S. festae* consists of 2 lots; 3 females from Esmeraldas, Ecuador (Cr. 198, Turin Museum) and 3 males and 4 females (not 4 males and 3 females as stated by Nobili, 1901:42) from Tumaco, Colombia (Cr. 91, Turin Museum). The latter material is indicated by the label to be the type-material and I therefore restrict the type-locality to Tumaco. The material of *S. biolleyi* consists of a large holotype male (*cb* 20.2 mm, USNM 32490) from Salinas de Caldera, Boca del Jesus Maria, Costa Rica.

There are clear differences among type-materials of the 3 nominal species but these are due, I believe, to differences in size. The morphological differences listed by Rathbun (1918) in her key are: (1) the frontal region does not widen distally in *S. festae* while it does widen in *S. occidentale* and *S. biolleyi*, and (2) the merus of the third leg in *S. biolleyi* has the length about 3 times the width while it is less than 3 times the width in *S. occidentale*. There are also some differences between *S. festae* from Ecuador and *S. occidentale* from Panama in the

strength of the tubercles on the chelae; the former having stronger tubercles. The differences in the form of the front and in the length-width ratio of the merus are size related. Small specimens have relatively wider legs and a front that does not widen distinctly distally; specimens in a range of sizes from a single locality will contain individuals which bridge the differences listed by Rathbun (1918). The differences in strength of the tubercles seem to depend on the stage of the molt cycle. Newly molted individuals seem to have more acute tubercles than individuals that appear ready to molt.

Sesarma (*Holometopus*) *angustum* Smith, 1870

Figures 3i–3m, 4, 5

Sesarma angusta Smith, 1870: 159 (type-locality Pearl Islands, Panama).
S. (Sesarma) ophioderma Nobili, 1901: 44 (type-locality Esmeraldas, Ecuador).

Sesarma (Sesarma) ophioderma: Rathbun, 1918: 297.

Sesarma (Holometopus) angustum: Rathbun, 1918: 314, pl. 92.

Sesarma angustum: Holthuis, 1954: 37.

Sesarma (Holometopus) angustum: Bott, 1955: 64, fig. 5.

Material examined (Coll. no. refers to specimens listed in Table 2):

Ecuador, Esmeraldas; 1 ♀ (Coll. no. 10) (Holotype of *S. ophioderma*)
E. Festa coll.; Turin Museum C r 138.

Panama, Pearl Islands; 8 ♂, 3 ♀ (Coll. no. 7), Rey Island; 3 February 1973; L. G. Abele coll.—1 ♂, 1 ♀ (Coll. no. 8), Canas Island; 18 May 1973; L. G. Abele coll.—6 ♂, 10 ♀ (Coll. no. 9), Senora Island; 30 January 1971; L. G. Abele, T. A. Biffar coll.—9 ♂, 3 ♀, Saboga Island; 5 January 1973; L. G. Abele coll.—4 ♀, Mina Island; 13 June 1973; L. G. Abele, R. Dressler coll.—3 ♂, 1 ♀ (Coll. no. 6); Pacheca Island; 5 January 1973; L. G. Abele coll.—1 ♀; Pedro Gonzales Island; 13 June 1973; L. G. Abele, R. Dressler coll.—1 ♀ (Holotype of *S. angustum*, YPMNH); F. H. Bradley coll.—1 ♀ (Coll. no. 11); Chiriqui Province, Rio Tinta (3 mi west of Rio Tabasara on Sona-Remedios Road); 11 November 1961; H. L. Loftin, E. L. Tyson coll.

Costa Rica, Cocos Island; 1 ♂ (Coll. no. 12); 12 August 1973; L. G. Abele coll.

Description: The carapace is slightly longer at the midline than wide; the ratio cl/cb is 1.04 ± 0.03 in males and 1.00 ± 0.02 in females. The ratio is somewhat biased by taking the cl measurement at midline since the front is concave at that point and the carapace is actually longer on either side of the midline. Small males and especially females tend to have the cl/cb ratio closer to unity. The lateral margins of the carapace are about equidistant throughout their length; the outer orbital angle is acute with 2 distinct emarginations posterior to it. The dorsal surface of the carapace is covered with depressed granules that are subacute on the interorbital region. The interorbital region is subdivided into 4 lobes; a deep sinus separates the large and distinct submedian pair.

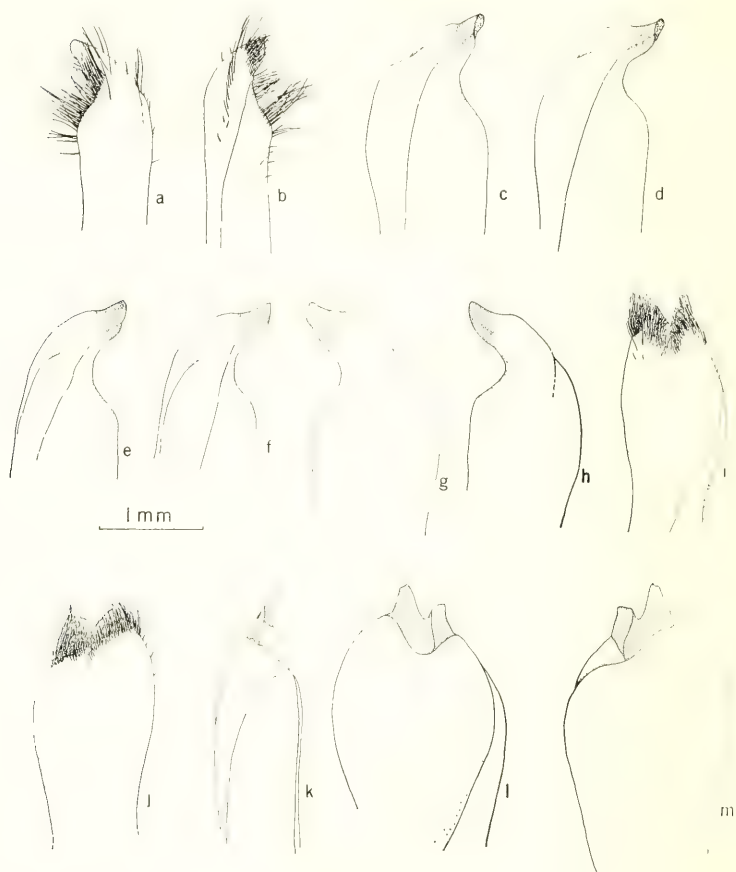


FIG. 3. Right male gonopods of *Sesarma*: a, Posterior view; b, Anterior view, *S. occidentale* from the Pearl Islands, Panama. c, Anterior view; e, Anterior view; g, Posterior view, holotype of *S. biolleyi*. d, Anterior view; f, Anterior view; h, Posterior view, holotype of *S. occidentale*. i, Anterior view; j, Posterior view; k, Lateral view; l, Anterior view; n, Posterior view, *S. angustum* from the Pearl Islands, Panama.

The lateral lobes are low with granules present. The frontal region is about 0.50 of the carapace breadth and distinctly concave; there is a median sinus, and 2 smaller lateral ones along the distal margin. The frontal region does not increase in width distally. The carapace is not inflated.

The eyes are well developed and pigmented.



FIG. 4. *Sesarma ophioderma* Nobili. Holotype female, Turin Museum 138.

The basal antennular segment is swollen, granulated and placed beneath the frontal margin. The basal antennal segment arises at the lateral part of the antennula and forms part of the lower orbit fitting up against a narrow triangular lobe. A groove (Verwey's groove; Hagen, in press) extends from the exhalant opening along the pterygostomial region to about the posterior margin of the orbit. An oblique groove extends from each end of Verwey's groove meeting beneath it and forming a wide triangular region.

The third maxillipeds do not meet and each has an oblique row of pubescence on the segment proximal to the palp.

The chelipeds are sexually dimorphic; in general, male chelipeds are more robust than females. In both sexes, the medial posterior edge and the lateral inferior edge of the merus are serrated. The medial anterior border is armed with teeth and expanded distally, especially in males. The carpus is covered with acute granules. The chelae of both sexes are covered with granules; they tend to be low on the lateral surface but acute on the medial surface and margins and on the dorsal surface of the movable finger. The dorsal surface of the palm has a poorly defined row of acute tubercles. Males tend to have 4 teeth on the immovable finger and 5 teeth on the movable one; the tips are somewhat spooned but do not meet evenly. Females tend to have 5 teeth on the immovable and 6 on the movable finger; the tips are spooned and fit evenly together.

The walking legs are long and relatively slender; in order of increasing length they are: first, fourth, second and third. The merus length to width ratio of the third ranges from 2.50 to 3.0 (2.78 ± 0.14); the ratio increases with increasing size and is greater in males than females (Table 2). The merus is slightly less than twice of the length of the carpus,

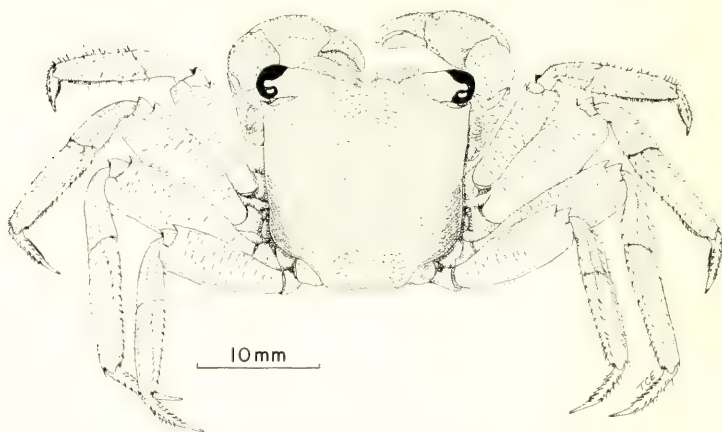


FIG. 5. *Sesarma angustum* Smith. Male from Pearl Islands, Panama.

about 1.3 times the length of the propodus and about twice as long as the dactylus. There is thick, dark pubescence along the ventral border of the propodus and dactylus of the first and second walking legs of males; it is absent in females. The propodi and dactyli of the walking legs are armed with small, black spines; on the ventral margin of the propodus and on both margins of the dactylus. Some data are presented in Table 2. For the propodus, $10 + 2$ indicates that 10 spines, each a member of a separated pair, are on the ventral border and there are 2 paired spines on the distal margin. For the dactylus, $4/3$ indicates that there are 2 poorly defined dorsal rows of 4 spines each and 2 poorly defined ventral rows of 3 spines each.

The male abdomen is subtriangular in outline; the length of the telson is slightly greater than the width. The female abdomen is semicircular in outline.

The male gonopod is quite different from other American species of *Sesarma* in that parts of the shaft are membranous or weakly calcified. The laterally compressed, amber-colored endpiece consists of 2 unequal lobes dorsoventrally separated by a large sinus.

The female gonopore is set deep in the sternum; there are anterior and posterior extensions that enclose the medial part.

Measurements: Males, *cb* 4.9 to 20.9 mm; females, *cb* 7.5 to 17.8 mm. Males larger than about 11.0 mm appear to be sexually mature while females appear to attain sexual maturity at about 12.0 mm. No ovigerous females were observed during the present study.

Type-locality: Pearl Islands, Gulf of Panama, Panama.

Distribution: This species has been reported from El Salvador, Costa Rica, Panama and Ecuador.

TABLE 2. Morphological measurements of *Sesarma augustum* Smith, 1870.

	<i>cl</i>	<i>cb</i>	<i>iw</i>	<i>aw</i>	<i>al</i>	<i>rdl</i>	<i>rch</i>	<i>rcw</i>	<i>lcl</i>	<i>lch</i>	<i>lcw</i>	Fourth Pereiopod					Fifth Pereiopod					Coll. no.				
												<i>ml</i>	<i>mw</i>	<i>c</i>	<i>p</i>	<i>ps</i>	<i>d</i>	<i>ds</i>	<i>p</i>	<i>ps</i>	<i>d</i>		<i>ds</i>			
Males																										
	4.9	4.9	2.3	1.4	2.9	2.3	1.0	0.7	2.4	1.0	0.7	3.9	1.4	2.0	2.9	4 + 1	2.0	4/3	2.9	1.0	1.0	2.1	3 + 2	1.8	1/2	6
	8.2	7.9	4.0	2.5	4.8	3.8	1.8	1.2	3.9	1.8	1.1	6.3	2.5	3.3	4.8	4 + 1	3.0	2/4	4.8	1.9	2.5	3.3	4 + 1	2.7	3/3	9
	8.9	8.7	4.3	2.8	4.5	4.3	2.1	1.4	4.2	2.1	1.4	6.8	2.6	3.6	5.0	9 + 2	3.3	2/3	5.3	2.1	2.9	3.5	4 + 2	2.8	2/4	9
	9.1	9.0	4.7	2.9	5.0	4.5	2.1	1.5	4.4	2.1	1.3	7.7	2.8	3.8	5.9	10 + 2	3.8	3/4	6.0	2.2	3.5	4.3	7 + 2	3.3	3/3	8
	12.5	11.8	6.1	4.3	7.7	7.2	3.8	2.6	7.7	3.9	2.7	10.2	3.6	5.3	8.2	10 + 1	5.2	2/4	7.7	2.8	4.5	6.0	8 + 0	4.5	4/6	7
	14.1	13.2	7.0	4.7	8.1	8.4	4.5	3.2	8.0	4.5	3.0	11.5	3.8	6.0	9.0	10 + 2	5.5	4/5	8.9	3.4	5.0	6.7	9 + 2	4.8	5/6	7
	16.3	15.9	8.3	5.3	9.7	10.0	6.1	4.3	10.1	4.3	6.3	—	—	—	—	—	—	—	10.0	3.5	5.8	7.8	8 + 2	5.7	5/6	7
	17.7	16.1	9.1	5.8	10.1	12.2	6.8	4.4	11.3	6.5	4.4	13.5	4.7	6.5	11.0	10 + 2	6.7	4/6	10.6	4.0	6.7	8.5	10 + 2	6.0	7/9	7
	18.9	18.3	9.9	6.3	11.3	12.9	7.3	5.0	11.7	6.0	4.3	13.5	4.7	6.5	11.0	12 + 2	6.5	8/5	11.5	4.3	6.5	9.1	7 + 2	5.5	7/5	7
	21.4	20.9	10.2	6.7	11.4	12.3	6.7	4.7	15.0	9.3	6.0	15.8	5.7	7.8	12.1	11 + 3	7.3	4/4	13.0	5.0	7.6	10.3	9 + 2	7.4	9/7	12
Females																										
	7.3	7.5	3.7	3.3	4.0	3.7	1.6	1.2	3.8	1.6	1.2	5.9	2.2	2.9	4.4	8 + 1	2.9	1/4	4.3	1.8	2.5	3.1	5 + 1	2.4	4/4	9
	7.9	8.1	4.0	3.1	4.4	3.8	1.8	1.2	3.8	1.7	1.2	6.5	2.5	3.4	4.7	5 + 1	3.2	2/3	4.9	1.8	2.8	3.5	4 + 1	2.8	3/4	8
	8.6	8.5	4.3	3.5	5.0	4.1	1.8	1.2	4.2	1.8	1.3	6.7	2.6	3.5	5.1	9 + 2	3.3	2/4	5.0	2.0	2.7	3.6	5 + 1	2.7	3/5	9
	8.6	8.8	4.4	4.3	4.9	4.2	1.8	1.2	4.1	1.8	1.2	7.0	2.5	3.4	5.2	8 + 2	3.3	4/4	5.3	2.0	2.9	4.1	7 + 2	3.2	4/4	10
	9.9	9.8	4.8	4.7	5.8	4.6	2.1	1.4	4.8	2.1	1.4	7.9	2.9	4.0	5.7	6 + 2	3.8	4/4	5.7	2.3	3.1	4.3	6 + 0	3.3	3/5	9
	12.7	12.5	6.4	8.8	8.1	6.5	2.9	2.0	6.3	2.8	1.9	9.8	3.7	5.1	7.6	10 + 2	4.7	2/3	7.4	3.0	4.3	5.4	5 + 2	4.2	4/7	9
	13.0	13.0	6.6	8.8	7.4	6.4	3.0	2.0	6.6	3.2	2.0	8.7	3.0	4.7	6.9	6 + 2	4.7	3/4	7.5	2.7	4.4	5.2	8 + 0	4.2	3/6	11
	16.9	16.5	8.4	12.2	11.2	8.8	4.4	2.9	9.2	4.1	2.9	13.3	4.8	6.5	10.7	12 + 3	6.3	3/4	11.0	4.4	6.3	8.1	9 + 2	6.0	5/6	6
	17.0	16.9	8.5	12.6	11.9	8.7	4.3	2.7	8.6	4.3	2.8	12.5	5.0	6.8	9.6	11 + 2	6.0	6/5	9.7	4.0	5.8	7.6	9 + 3	5.8	6/7	9
	18.1	17.8	8.7	13.8	12.4	9.4	4.6	2.9	9.5	4.5	3.0	13.0	5.2	6.7	10.2	11 + 2	5.5	5/5	10.8	4.3	6.2	7.9	9 + 2	5.8	6/7	9

Habitat: *Sesarma angustum* is common in and on the banks of freshwater coastal streams, especially on islands. It was not collected more than 100 m upstream from the mouth of any stream.

Remarks: Type-materials of both *S. angustum* and *S. ophioderma* were examined during the present study. Nobili (1901) placed *S. ophioderma* in the subgenus *Sesarma* because of the presence of 2 small lobes posterior to the outer orbital angle. Nobili's statement on this character led Rathbun (1918) also to place *ophioderma* in the subgenus *Sesarma*. The presence of anterolateral lobes plus Nobili's statement that the length and breadth of the carapace are subequal has led to the difficulty in identifying this species. However, as Holthuis (1954) noted, there are anterolateral lobes present on *S. angustum*. They are somewhat variable in their development but they are quite distinct in smaller individuals. In addition, smaller specimens, especially females (Table 2), tend to have the carapace length and breadth subequal. Thus, based on the characters just mentioned and comparison of a series of specimens, it is concluded that *Sesarma ophioderma* Nobili is a junior synonym of *S. angustum* Smith.

ACKNOWLEDGMENTS

I thank Dr. Orsetta Elter, Curator of the Museo Ed Instituto Di Zoologica Sistemica della Universita Di Torino for his patience, time and trouble involved in my numerous requests for material; Dr. Raymond B. Manning, Division of Crustacea, USNM, for the loan of material and for assisting me during a visit to that institution; Dr. W. T. Hartman, Yale University for his hospitality during my visit and for answering requests for material. The illustrations were rendered by Ms. Teresa C. Ellis. Support was provided by NSF grant DEB 75-22583.

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PROCEEDINGS
OF THE
BIOLOGICAL SOCIETY OF WASHINGTONFRESHWATER TRICLADS (TURBELLARIA) OF
NORTH AMERICA. X. THREE NEW SPECIES OF
PHAGOCATA FROM THE EASTERN UNITED STATES

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The genus *Phagocata* is well represented in North America. The latest revision of the North American planarian fauna (Kenk, 1972) lists 12 species of the genus. In the meantime, the following changes have been made in this list: *Phagocata monopharyngea* Hyman proved to be identical with *P. velata* (Stringer) and *P. vernalis* Kenk turned out to be the male phase of the protandrous *Hymanella retenuova* Castle (Kenk et al., in preparation). One new species has been added, the western *P. fauvecetti* Ball & Gourbault (1975), a species similar to *P. velata*.

The writer wishes to express his deep appreciation to the various colleagues who have furnished the materials described in this paper: Dr. David C. Culver of Northwestern University, Dr. John R. Holsinger of Old Dominion University, Mr. Sam L. H. Fuller of the Academy of Natural Sciences in Philadelphia, and Mr. Arnold Norden, graduate student of Towson State College.

The types of the new species have been deposited in the National Museum of Natural History, Smithsonian Institution.

Phagocata angusta new species
Figures 1A, 2

Type-material: Holotype, set of sagittal sections on 3 slides (USNM 53620); paratypes, sagittal sections of 5 specimens on 6 slides (USNM 53621-53625).

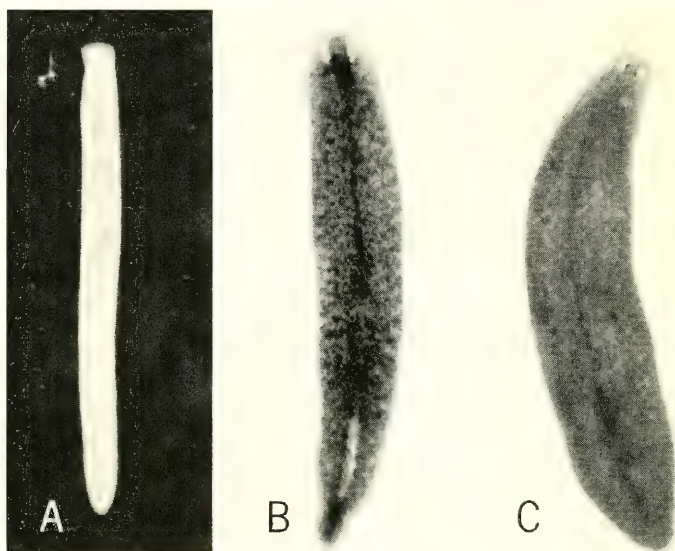


FIG. 1. Photographs of living specimens. A, *Phagocata angusta* n. sp., $\times 8$; B, *P. virilis* n. sp., $\times 7$; C, *P. nordeni* n. sp., $\times 6$.

External features (Fig. 1A): This is a white species, externally very similar to *Phagocata morgani* (Stevens and Boring) but of more slender shape, measuring up to 10 mm in length and 0.7 mm in width. The anterior end is truncate, with a straight or slightly convex frontal margin and rounded lateral edges which protrude laterally when the worm is in gliding locomotion. Eyes are 2, very small, situated at a mutual distance of about $\frac{1}{4}$ the width of the head at eye level and far removed from the frontal margin. The intestinal area begins posterior to the level of the eyes. The pharynx is rather long, located behind the middle of the body, occupying the fourth fifth of the body length. The copulatory apparatus is seen as a transparent area behind the pharynx.

Anatomy: The eyes are very small, the diameter of the pigment cup being only 15–22 μm . They are situated close to the dorsal side of the cerebral ganglion.

The reproductive system of 7 specimens was examined in sagittal serial sections. The testes are subventral, some of them very large and extending through the entire dorsoventral space of the body. They are arranged, on either side, in a longitudinal band reaching posteriorly to the level of the pharynx. The 2 ovaries, each provided with a large lobed parovarium, are situated behind the second lateral branches of the anterior intestinal ramus. In the copulatory complex (Fig. 2), the penis has a muscular bulb (*bp*) of moderate size and a rather short, generally plug-shaped

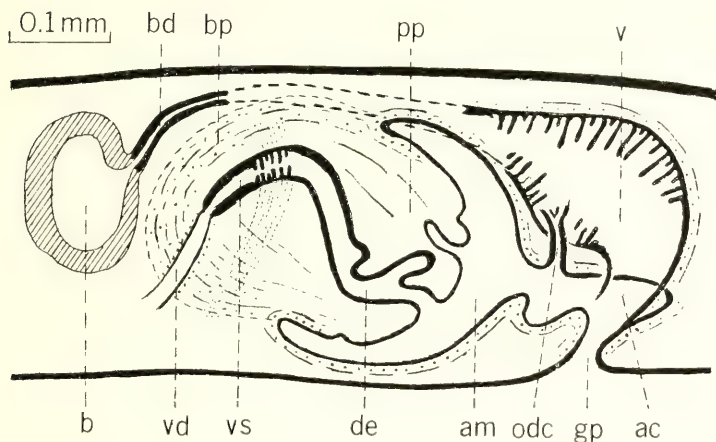


FIG. 2. *Phagocata angusta*, semidiagrammatic view of copulatory apparatus in sagittal section. Abbreviations used in Fig. 2–4: *ac*, common atrium; *am*, male atrium; *b*, copulatory bursa; *bd*, bursal canal or duct; *bp*, penis bulb; *de*, ejaculatory duct; *gp*, gonopore; *m*, mouth; *odc*, common oviduct; *pp*, penis papilla; *v*, vagina; *vd*, vas deferens or sperm duct; *vs*, seminal vesicle.

papilla (*pp*) with somewhat irregular outline. The papilla lacks the muscular wart which is characteristic of the related *P. morgani*. The penis lumen begins in the bulb as an elongated cavity (*vs*) extending first posterodorsally, then arching posteroventrally to open into a variously shaped papillar cavity (*de*) which often shows lateral extensions and sinuses and empties into the atrial cavity near the rounded tip of the papilla. The anterior part of the bulbar lumen is lined with tall epithelial cells of a secretory nature. Then follows a section in which the cells project club-like into the lumen and numerous eosinophilic glands enter the cavity. In the papilla, the lumen is lined with a flattened infranucleate epithelium. Muscle fibers seem to be absent or, at least, are not conspicuous around the penial lumen, which may account for the variability of its shape. The papilla itself is covered with a flattened epithelium, nucleate at the base and infranucleate in the more distal parts of the papilla. Apparently the bulbar lumen corresponds to a seminal vesicle and the cavity in the papilla to a modified ejaculatory duct. The vasa deferentia (*vd*) approach the penis bulb as tortuous spermiductal vesicles, enter it anterolaterally or anteroventrally, and open into the bulbar part of the penis lumen.

The cavity surrounding the papilla, the male atrium (*am*), narrows posteriorly and receives the outlet of the common oviduct (*odc*) from the

dorsal side. It connects with a small posterior compartment, the common atrium (*ac*).

The copulatory bursa (*b*) is a rounded sac situated anterior to the penis bulb. Its outlet, the bursal duct (*bd*), begins as a rather narrow canal proceeding posteriorly above the penis or somewhat laterally to it. The lining of this anterior part is generally a smooth epithelium. Behind the male atrium, the duct widens considerably and the epithelial lining projects villus-like into the lumen. This part, which is histologically different from the anterior section, may be called a vagina (*v*).

Distribution and ecology: The species is known so far from only one locality, Harper Cave in Tucker County, West Virginia. It was collected first by John R. Holsinger and David C. Culver in a small pool with muddy bottom near the entrance of the cave, on 19 May 1973 (14 specimens); and again by Arnold Norden and Beth Ball on 2 January 1974 (4 specimens). The cave also contained two species of kenkiids, *Macrocotyla hoffmasteri* (Hyman) and *Sphalloplana culveri* Kenk (in press). It is the "*Phagocata* sp." mentioned in 2 of my papers (Kenk, 1975: 336 and 1976 [in press]).

Taxonomic position: *Phagocata angusta* is externally very similar to several North American white planariids. From the sympatric *Planaria occulta* Kenk it differs by the lack of the median extension of the anterior gut trunk between the eyes and, anatomically, by the lack of an adeno-dactyl in the copulatory complex; from the Alaskan *Phagocata nivea* Kenk, by the restriction of the testes to the prepharyngeal region and by the anatomy of the penis; from *Phagocata oregonensis* Hyman, chiefly by the penial anatomy; and from the sympatric *Phagocata morgani* (Stevens and Boring), to which it seems to be most closely related, by several characteristics: a more slender shape, lack of the wart-like structure on the penis papilla, and a different configuration of the penial lumen. The covering of the penis papilla and the lining of the papillar lumen are infranucleate, while in *P. morgani* they are normal nucleate epithelia. The villus-like projections of the cells lining the vagina are also a good distinguishing character. The name of the species, *angusta* (Latin, narrow), refers to its slender shape.

***Phagocata virilis* new species**

Figures 1B, 3

Type-material: Holotype, set of sagittal sections on 4 slides (USNM 53626); paratypes, 3 sets of sagittal sections on 11 slides (USNM 53627-53629), set of transverse sections on 4 slides (USNM 53630), and set of horizontal sections on 2 slides (USNM 53631).

External features (Fig. 1B): A pigmented species, measuring in life up to 10 mm in length and 1.3 mm in width. The head is truncate, with a straight frontal margin and rounded lateral edges. There is no constriction or neck behind the anterior end. The lateral margins run parallel in the greater part of the body and the posterior end is rather pointed. The distance of the 2 eyes from each other is about $\frac{1}{4}$ to $\frac{1}{3}$ the width of the

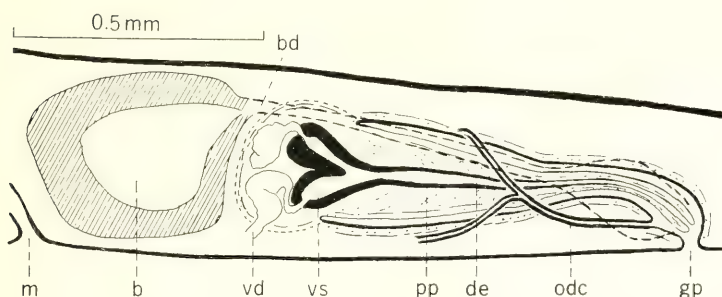


FIG. 3. *Phagocata virilis*, copulatory apparatus. For abbreviations see Fig. 2.

head, their distance from the lateral margin slightly smaller than that from the frontal margin. The pigmentation is dark brown both dorsally and ventrally, appearing somewhat mottled under the dissecting microscope.

Anatomy: The 2 ovaries, each with a large lobed parovarium, are located below or behind the first pair of branches of the anterior intestinal trunk. The testes are predominantly ventral, situated on either side of the midline in a zone beginning immediately behind the ovaries and reaching posteriorly to the level of the copulatory complex. They are developed in only a moderate number, not as closely packed as in most other species of the genus. The copulatory apparatus (Fig. 3) is characterized by a pronounced asymmetry of its components. The penis is situated in the midline and has a rounded bulb of moderate size, with muscle fibers developed only at its periphery. The penis papilla (*pp*) is exceedingly long and conical. The penial lumen consists of a bulbar cavity or seminal vesicle (*vs*) divided into 2 anterolateral lobes, the lobe of the right side being somewhat more dorsal than that of the left side. Toward the papilla, the cavity extends into a canal, the ejaculatory duct (*de*), which runs through the center of the papilla and opens at its tip. This duct is rather wide in its anterior half and tapers to a very narrow canal posteriorly. The seminal vesicle is lined with a tall epithelium of secretory cells. The lining of the widened part of the ejaculatory duct consists of a cuboidal epithelium pierced by many gland ducts with a granular eosinophilic secretion. The narrow distal part of the duct has a flattened epithelium without gland openings. The covering of the penis papilla is a very flattened nucleate epithelium. Below it is a layer of fine circular muscle fibers, followed by a sheet of longitudinal muscles. The 2 vasa deferentia approach the penis bulb as enlarged spermiductal vesicles and enter the bulb anterolaterally. In the bulb, each vas deference, filled with sperm, retains its expanded shape and, after some contortions, enters the lobe of the seminal vesicle of its side. The right oviduct, in the region of the male atrium, ascends to the dorsal side, pro-

ceeds in an arch across the atrium to the left side, and unites with the left oviduct to form the common oviduct (*ode*) which runs posteriorly on the left side of the midline and empties into the posterior part of the atrium close to the gonopore (*gp*). The copulatory bursa (*b*) is a large rounded sac. Its outlet, the bursal duct (*bd*), originates in the midline but gradually turns to the left and continues posteriorly to join the male atrium near the genital aperture. There is no common atrium. In the posterior part, the lumen of the bursal duct is somewhat widened, representing a vagina.

Asymmetry of the copulatory apparatus is frequently observed in planarians, usually caused by irregular contractions and twistings of the organs at the time of fixation. In our specimens, however, which had been killed by the application of a hot corrosive sublimate solution, distortions were minimal and were confined principally to a slight bending of the body producing an arched shape. Nevertheless, the asymmetrical arrangement of the bursal duct and the oviducts was evident in all 6 individuals examined and must be considered to be a normal characteristic of the species.

Distribution and ecology: *Phagocata virilis* was obtained in a seep on the bank of the Patuxent River, Prince Georges County, Maryland, located at McGruder Landing, about 5 miles northeast of the town of Poplar Hill. Seven specimens were collected by Sam L. H. Fuller on 4 February 1976, together with *Procotyla fluvialis* Leidy, and sent to me alive. When placed in a culture kept at 14° C, some specimens laid five cocoons by 21 March. The cocoons were oblong-ovoid, measuring 0.7–0.8 × 1.4–1.7 mm. The young animals that hatched in early April varied in length from 1.5 to 3 mm.

Taxonomic position: By its external appearance, *Phagocata virilis* is very similar to other North American pigmented planarian species with truncated head, from which it cannot be distinguished in life with certainty: *Phagocata velata* (Stringer), *P. bulbosa* Kenk, the western *P. crenophila* Carpenter, and the sympatric *Planaria dactyligera* Kenk. *P. velata*, when kept in a culture, shows asexual reproduction by fragmentation and encystment, which has not been observed in *P. virilis*. From *Planaria dactyligera*, our species differs by the lack of an adenodactyl and from *P. bulbosa* and *P. crenophila*, by the anatomy of its copulatory apparatus. The name of the species, *virilis* (Latin, masculine), refers to the highly developed male copulatory organ.

***Phagocata nordeni*, new species**

Figures 1C, 4

Type-material: Holotype, set of sagittal sections on 4 slides (USNM 53632); paratypes, set of sagittal sections on 3 slides (USNM 53633) and set of transverse sections of posterior part on 3 slides (USNM 53634).

External features (Fig. 1C): A pigmented polypharyngeal species, externally not distinguishable from the southern form of *Phagocata gracilis* (Haldeman) or from *P. woodworthi* Hyman. Mature specimens

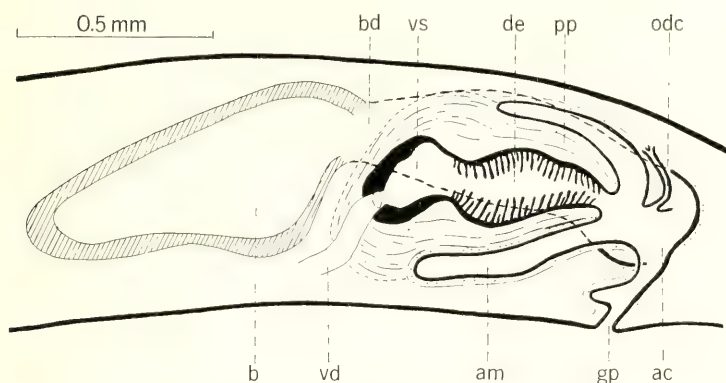


FIG. 4. *Phagocata nordeni*, copulatory apparatus. For abbreviations see Fig. 2.

are up to 15 mm long and 2.5 mm wide. Head truncate, with slightly convex frontal margin which may show a light central protuberance when the animal is gliding. The lateral edges of the head are rounded. Behind the head, a shallow narrowing may appear, but no conspicuous constriction. The lateral body margins gradually diverge, run parallel in the greater part of the body length, then converge again and meet in a rather pointed tail end. The distance between the 2 eyes is about $\frac{1}{3}$ the width of the head, their distance from the lateral margins slightly smaller than that from the frontal margin. The pigmentation is dark brown, almost black, on the dorsal side, with a darker median line in the posterior $\frac{2}{3}$ of the body. The ventral side is also pigmented, but somewhat lighter. The gonopore is visible as a white dot in the middle of the postpharyngeal section.

Anatomy: The species shares its polypharyngy with 2 other species of the genus *Phagocata*, *P. gracilis* (including *P. subterranea* Hyman) and *P. woodworthi*. As in those species, the mouth opening is not at the posterior end of the pharyngeal pouch, but somewhat more anterior.

The numerous testes are predominantly ventral, although a few individual follicles may be found in intermediate and even dorsal positions. The testicular zone reaches posteriorly almost to the tail end. The ovaries, equipped with parovaria, are situated below or behind the first or second lateral branches of the anterior intestine. In the copulatory apparatus (Fig. 4), the penis has a muscular bulb (*bp*) and a large, conical papilla (*pp*). The bulb contains a large cavity, the seminal vesicle (*vs*), lined with a tall secretory epithelium. Posteriorly, the cavity continues into a wide canal (*de*) which opens at the tip of the papilla. The lining of this canal is histologically quite different from that of the seminal vesicle. It consists of an epithelium of club-shaped cells which protrude villus-like into the lumen. The canal corresponds to a considerably expanded

ejaculatory duct. The outer covering of the penis papilla is a cuboidal epithelium underlaid by a thick sheet of fine circular muscles followed by a layer of longitudinal muscle fibers. The vasa deferentia (*vd*) enter the penis bulb anteroventrally, proceed medially and empty into the seminal vesicle separately. The male atrium (*am*) duplicates the shape of the penis papilla, narrows posteriorly, and connects with the small common atrium (*ac*). The common oviduct (*odc*) opens from the dorsal side at the transition between the 2 atria. The copulatory bursa (*b*) is a large sac in the usual position anterior to the penis bulb. It has a very wide outlet, the bursal canal (*bd*), which runs posteriorly on the right side of the penis and connects with the common genital atrium. It is histologically uniform throughout its length, not showing any terminal sphincter such as is seen in *P. woodworthi*. All epithelia of the copulatory apparatus are nucleate.

Distribution and ecology: *P. nordeni* was taken among vegetation in the outflow of Lake Harris, in a ditch along the west side of U.S. Road 27, 0.5 mile south of Leesburg, Lake County, Florida. Seven specimens were collected on 7 January 1976 by Arnold and Beth Norden and D. Franz and brought to me alive. The water temperature was 11° C. *Procotyla fluviatilis* Leidy also occurred in the locality.

Taxonomic position: *P. nordeni* is the third polypharyngeal species of the genus *Phagocata*. In life it cannot be distinguished from the other 2 species, *P. gracilis* and *P. woodworthi*. Anatomically it differs from *P. gracilis* by the structure of the penial lumen (see Kenk, 1970), in particular by the lack of a second seminal vesicle and by the shape and histology of the ejaculatory duct. From *P. woodworthi* it is differentiated by the lack of a sphincter on the bursal duct, the lack of a layer of interlaced circular and longitudinal muscle fibers in the penis papilla, and the configuration of the penial cavities. The species is named in honor of one of its collectors, Mr. Arnold Norden.

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PROCEEDINGS
OF THE
BIOLOGICAL SOCIETY OF WASHINGTON

ISOPOD CRUSTACEANS (EXCEPT ANTHURIDAE)
COLLECTED ON THE PRESIDENTIAL CRUISE OF
1938

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The isopods reported on herein were collected during an inspection cruise and fishing trip aboard the U.S.S. *Houston* in July and August of 1938 by President Franklin D. Roosevelt. Dr. Waldo L. Schmitt served as Naturalist during the cruise. From San Diego, the *Houston* sailed south along Lower California, then visited Socorro Island in the Revilla Gigedo Islands, stopped at Clipperton Island, and then headed south to the Galapagos Islands. Returning from the Galapagos, stops were made at Cocos Island, and after passing thru the Panama Canal, at Old Providence Island, in the Caribbean Sea east of Nicaragua. Further details of the cruise are given by Schmitt (1939). Isopods were obtained at all the above localities except the Galapagos.

Schmitt (1939: 7, footnote 4) stated that reports on the Presidential Cruise amphipods and isopods were being prepared by Clarence R. Shoemaker and James O. Maloney, respectively. The report on the amphipods appeared in due course (Shoemaker, 1942). Maloney compiled a preliminary list of the isopods, but a final manuscript was not completed before he left the Smithsonian Institution in 1945.

CIROLANIDAE

Cirolana parva Hansen
Figures 1-3

Cirolana parva Hansen, 1890: 340-341, pl. 2., fig. 6, 6b, pl. 3, fig. 1-1d.
—Richardson, 1900: 217; 1905: 111-114, figs. 93-95; 1912: 187.—

Moore, 1901: 167, pl. 8, figs. 6–8.—Stebbing, 1905: 12; 1910: 217.—Nobili, 1907: 421.—Barnard, 1914: 353a.—Chilton, 1924: 883–884, fig. 5; 1926: 180.—Monod, 1931: 3; 1933: 173; 1937: 15.—Nierstrasz, 1931: 151.—Edmondson, 1951: 192–194, fig. 4a–g.—Menzies and Frankenberg, 1966: 51, fig. 27.—Menzies and Glynn, 1968: 38–39, fig. 14C–D.—Miller, 1968: 15–16, fig. 4.—Schultz, 1969: 185.—Jones, 1976: 216–217.

Cirolana diminuta Menzies, 1962: 343–344, fig. 6A–F.—Schultz, 1969: 184, fig. 288.

Station 30–38, Old Providence Island, 6 Aug. 1939, shore, reef, and tidepool collecting: 1 specimen, 6.5 mm.

The characteristic form and armature of the telson and uropods, shown by Hansen (1890), Richardson (1905), Menzies and Frankenberg (1966), and Menzies and Glynn (1968) serves to identify the species. The rather broad frontal lamina and short clypeus (Fig. 1) are also helpful characters. Pereopod 1, not illustrated heretofore, is figured here (Fig. 2); as in *C. anadema* Glynn (1972) the merus is armed with a series of blunt spines on the opposable margin.

Distribution: Throughout the Caribbean, Gulf of Mexico, Florida, Bahamas, north to Georgia (31°32'N); west coast of Africa (Monod, 1931); Pacific coast of Mexico (Menzies, 1962); Hawaii (Edmondson, 1951); South Pacific; Indonesia; Indian Ocean ("This species is the commonest *Cirolana* in the Indian Ocean region."—Jones, 1976); Red Sea and Suez Canal.

Eurydice caudata Richardson

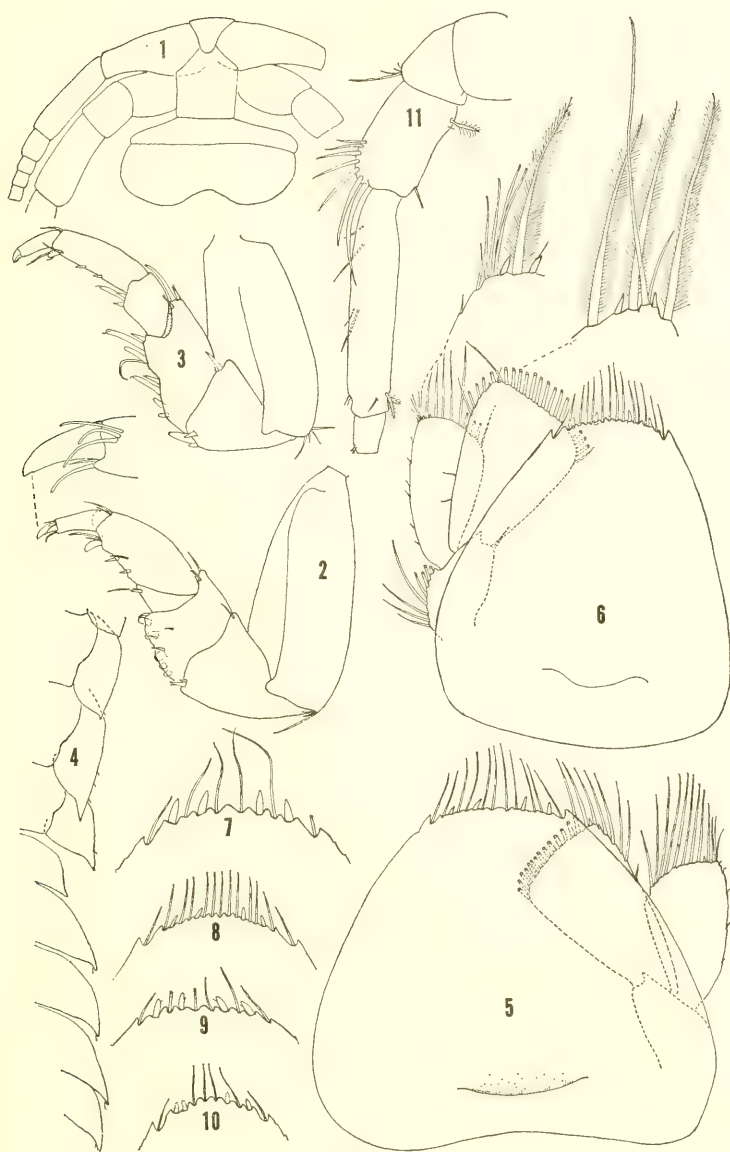
Figures 4–18, 34

Eurydice caudata Richardson, 1900: 217–218, fig. 3; 1901: 516; 1905: 124, fig. 107.—Steinbeck and Ricketts, 1941: 424.—Schultz, 1969: 173, fig. 265.

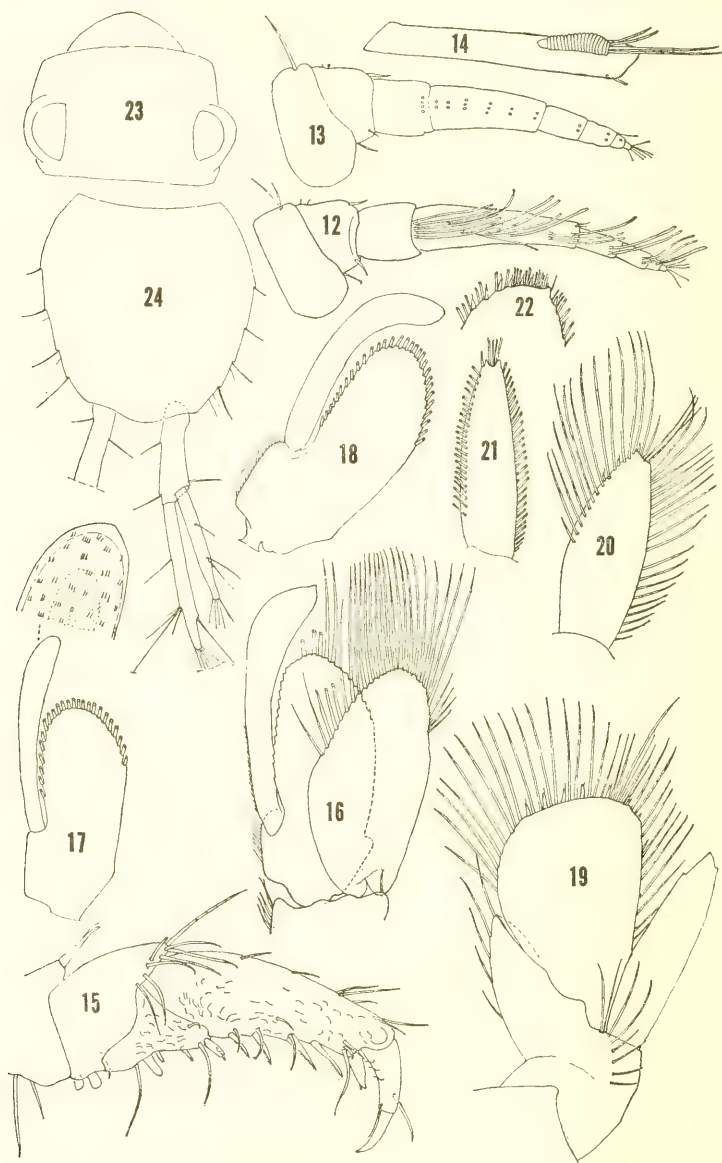
Eurydice branchuropus Menzies and Barnard, 1959: 32, figs. 26–27.—Schultz, 1966: 14; 1969: 173, fig. 266.

Station 28–38, Cocos Island, Chatham Bay, 3 August 1938, from bottom sample, mostly sand, depth 55 m: 2 manca (pereopod 7 undeveloped), 2.05 and 1.85 m.

This species has never been adequately described and illustrated. Since the Presidential Cruise specimens are very immature, some of the principal characters of the species are illustrated from a male syntype, 6.4 mm in length. Apical margin of telson about 0.4 greatest width of telson, delimited by pair of teeth; 4 spines on margin, central pair more widely spaced than others. Uropods not quite reaching apex of telson; each ramus with pair of spines at distolateral corner. Antenna 1, 4th segment elongate. Appendix masculina of pleopod 2 inserted slightly distal to proximal $\frac{1}{4}$ of medial margin of endopod; apex bent laterally, broadening and ending in point.



FIGS. 1-3. *Cirolana parva*: 1, Head, ventral; 2, Pereopod 1; 3, Pereopod 2. Fig. 4-10, *Eurydice caudata*: 4, Pereonites 5-7 and pleon, lateral, ♂ syntype; 5, Telson and uropods of same; 6, Telson and uropod, 5.4 mm ♂ from Clarion I.; 7-10, Apical margin of telson: 7, 2.05 mm manca, Cocos I.; 8, 4.5 mm ♂, La Libertad, Ecuador; 9, 1.85 mm manca, Cocos I.; 10, 4.5 mm ♀, Isabella I.; 11, Antenna 2, 5.4 mm ♂, Clarion I.



FIGS. 12-18. *Eurydice caudata*: 12, Antenna 1, ♂ syntype; 13, Antenna 1, ♂, Clarion I. (circles show insertions of esthetes); 14, Antenna 2, flagellar segment 14, ♂, Clarion I.; 15, Pereopod 1, ♂, Clarion I.; 16, Pleopod 2, ♂ syntype; 17, Pleopod 2 endopod, ♂, Clarion I.; 18, Pleopod

The range extension provided by the Presidential Cruise specimens is considerable, since *E. caudata* has heretofore been reported only from Catalina Island, California (type-locality), the Gulf of California (Steinbeck and Ricketts, 1941) and coastal waters of southern California and nearby Lower California (Menzies and Barnard, 1959; Schultz, 1966). The USNM collections include samples of *E. caudata* that document its wide distribution (Fig. 34). North of the type-locality it has been collected at San Clemente Island and off Point Vicente. Farther south, it has been found at 2 of the Revilla Gigedo Islands, Socorro Island and Clarion Island, and at Isla Isabella (ca. 50 km NE of Tres Marias Is.). The southernmost record in the Northern Hemisphere is the Cocos Island sample of the Presidential Cruise, but there is one USNM sample from La Libertad, Ecuador ($2^{\circ}14'S$).

Eurydice branchuopus was described from southern California by Menzies and Barnard (1959), but reduced to a synonym of the Atlantic *Eurydice littoralis* (Moore), by Menzies and Glynn (1968). However, as clearly shown by Menzies and Glynn (1968: fig. 4B) and by Moreira (1972: fig. 25), *E. littoralis* differs in having the inner pair of spines on the apical margin of the telson much longer than the outer pair. In *E. branchuopus*, as in *E. caudata*, the 4 apical spines are subequal. I consider *E. branchuopus* a synonym of *E. caudata*. Menzies and Barnard separated their species from *E. caudata* by its shorter 1st antenna and rounded uropodal rami. The difference in antennal length is a secondary sexual character, and as shown herein (Figs. 5–6), the uropodal rami of *E. caudata* are rounded, not truncate as described and illustrated by Richardson.

EXCORALLANIDAE

Excorallana tricornis occidentalis Richardson

Figures 19–20, 25

Corallana tricornis Hansen, 1890: 379–381 [specimen from El Realejo, Nicaragua, only].

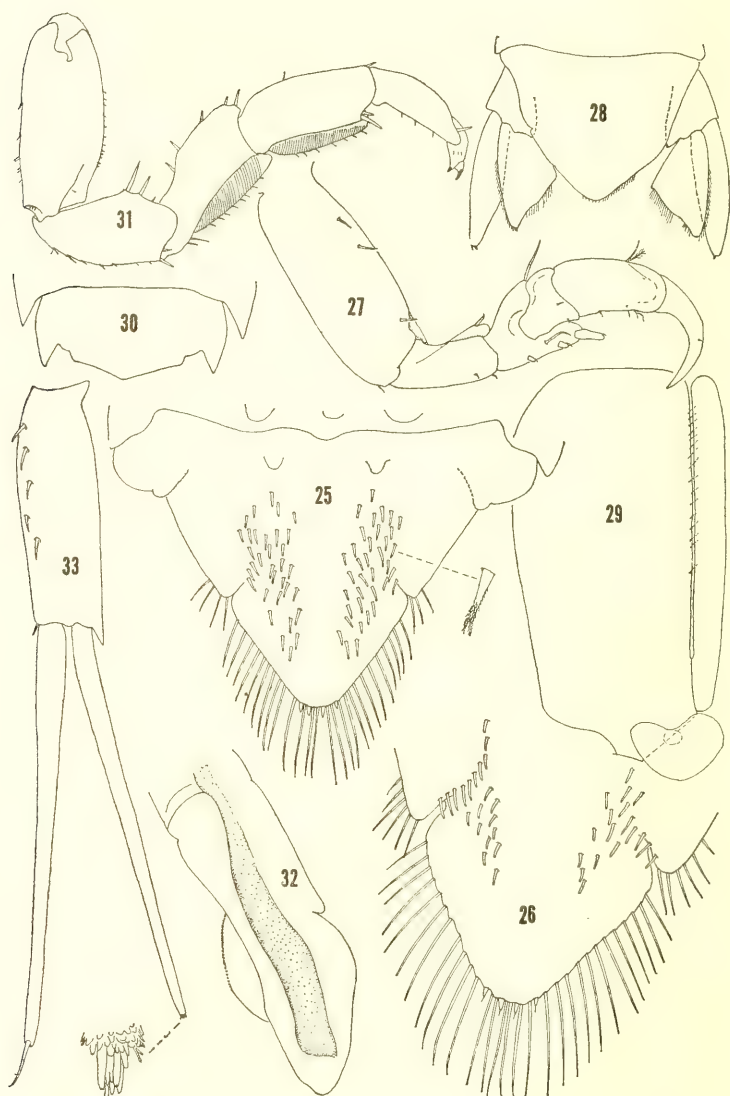
Excorallana tricornis occidentalis Richardson, 1905: 141.

Excorallana tricornis (Hansen).—Steinbeck and Ricketts, 1941: 424.

Off San Jose del Cabo Bay, Lower California ($23^{\circ}02'N$, $109^{\circ}40'W$), 19 July 1938.—On body surface and in nostrils of gulf grouper (*Mycter-*

←

2 endopod, ♂, La Libertad, Ecuador. Fig. 19–20, *Excorallana tricornis occidentalis*, Presidential Cruise, 5.1 mm: 19, Left uropod, ventral; 20, Exopod of left uropod. Fig. 21–22, *Excorallana tricornis tricornis*, Dry Tortugas, Fla.: 21, Exopod of left uropod; 22, Apex of endopod of left uropod. 23–24, Unidentified Janiridae, Presidential Cruise: 23, Head, dorsal; 24, Telson and uropods.



FIGS. 25-33. *Excorallana tricornis occidentalis*, 6.6 mm ♂, Presidential Cruise, telson; 26, *E. t. tricornis*, Dry Tortugas, Fla., posterior part of telson; 27, *Rocinela signata*, Socorro I., pereopod 1, lateral; 28, *Nerocila californica*, ♂, Magdalena Bay, telson and uropods; 29, Same, pleopod 2. 30-33, *Ligia occidentalis*, ♂, Cedros I.: 30, Telson; 31, Pereopod 1, medial; 32, Apex of appendix masculina, anterior; 33, Right uropod, dorsal.

perca jordani (Jenkins and Evermann), 24 specimens, 3.6–8.6 mm.—From jack-crevally (*Caranx caninus* Gunther), 1 manca.

Richardson (1905) proposed recognition of the subspecies *occidentalis* for 3 specimens of *E. tricornis* from an unspecified locality in the Gulf of California. These syntypic specimens were actually collected at Albatross station 2826 (24°12'N, 109°55'W) in the southwestern Gulf, and according to Richardson, “. . . differ from the specimens of the East coast only in having larger tubercles on the abdominal segments on either side of the median longitudinal groove”. In the 2 female syntypes there are prominent pairs of tubercles on pleonites 4 and 5 and at the base of the telson. One female has a slightly developed pair of tubercles on pleonite 3. The 6.3 mm male syntype, like the Presidential Cruise specimens, has no large tubercles on the pleonites, but has a moderately well developed pair at the base of the telson. The development of pleonal tubercles on the female syntypes could be related to their greater maturity (both ovigerous, with body lengths of 7.1 and 8.5 mm). Further evidence of variation in pleonal tuberculation is given by a 6.8 mm female from Concepcion Bay, Gulf of California (USNM 86381), which has well developed tubercles only on pleonite 5.

Despite the variability in the character upon which Richardson based her subspecies, *E. t. occidentalis* can be separated by other characters: 1. The margins of the lateral incisions of the telson in *E. t. tricornis* are separated by a gap; in *E. t. occidentalis* they are not (compare Figs. 25 and 26). 2. The uropodal exopod of *E. t. tricornis* is narrower in relation to its length, and the terminal setae are inserted into a nearly symmetrical notch (Fig. 21). In *E. t. occidentalis* this notch is shallower, and its medial wall is much longer than its lateral wall (Fig. 20).

Distribution: Probably throughout the Panamic Province.

AEGIDAE

Rocinela signata Schioedte and Meinert

Figure 27

Rocinela signata Schioedte and Meinert, 1879: 399–401, pl. 13, fig. 3.—

Richardson, 1898: 11 [in key]; 1901: 524; 1905: 209–210, figs. 211–212; 1912: 189–190.—Moore, 1901: 171, pl. 10, fig. 2.—Menzies and Glynn, 1968: 45, fig. 20E–G.—Schultz, 1969: 201, fig. 316.

Rocinela aries Schioedte and Meinert, 1879: 401–403, pl. 13, figs. 7–8.

—Richardson, 1898: 11 [in key]; 1899a: 828; 1899b: 170; 1905: 210–211, figs. 213–215; 1914: 362.—Steinbeck and Ricketts, 1941: 425.—Menzies, 1962: 345, fig. 5.—Schultz, 1969: 201, fig. 317.

Off San Jose del Cabo Bay, Lower California, 19 July 1938, from gills of striped pargo, *Hoplopagrus guntheri* Gill, 1 specimen, 7.3 mm.

Station 8–38, Socorro Island, 20 July 1938, dredged from sandy bottom, 13–15 m; 1 specimen, 5.8 mm.

The distinction between the Caribbean *R. signata* and *R. aries*, from the Gulf of California and west coast of Mexico, has long been doubtful,

and I agree with Menzies and Glynn (1968) that they are conspecific. In her key, Richardson (1905) separated them by the propus of pereopods 1-3 being unarmed in *R. signata*, but bearing a single spine in *R. aries*. Menzies and Glynn found a spine on the distal part of the propal margin in Puerto Rican specimens of *R. signata*, and I have found the same spine in specimens from Quintana Roo, Mexico. Richardson erroneously described and illustrated 2 blunt spines on the merus and 1 on the carpus; there are actually 3 spines on the merus and none on the carpus.

Distribution: In the Pacific from San Quintin Bay, Lower California (Menzies, 1962), and the Gulf of California, south to Panama, including Socorro Island. In the Atlantic, widespread in the Gulf of Mexico and Caribbean Sea, south to Recife, Brazil (Schioedte and Meinert, 1879).

CYMOTHOIDAE

Nerocila californica Schioedte and Meinert

Figures 28-29

Nerocila californica Schioedte and Meinert.—Richardson, 1905: 221-223, figs. 224-226 [synonymy].—Schultz, 1969: 151, fig. 224.

Magdalena Bay, Lower California, from broomtail grouper, *Mycteroperca xenarcha* Jordan, 18 July 1938, 1 ♂, 12.0 mm.

The specimen still has the plumose setae on the telson and uropods characteristic of the juvenile pelagic stage. The endopod of pleopod 2, with its appendix masculina, is illustrated here.

Distribution: Southern California to Panama.

JANIRIDAE

Genus and Species undetermined

Figures 23-24

Station 30-38, Old Providence Island, 6 August 1938, shore, reef, and tidepool collecting: 1 specimen, in poor condition, 1.7 mm.

As Menzies and Glynn (1968) pointed out, "... the genera *Janiropsis*, *Janira*, and *Bagatus* are indistinguishable from each other except for the characteristics of the male gnathopod." The present specimen is a female, and I cannot identify it beyond the family level.

LIGIIDAE

Ligia (Megaligia) occidentalis Dana

Figures 30-33

Ligia (Megaligia) occidentalis Dana.—Van Name, 1936: 50-51, figs. 5g, 9 [synonymy].

Ligyda occidentalis (Dana).—Steinbeck and Ricketts, 1941: 425.

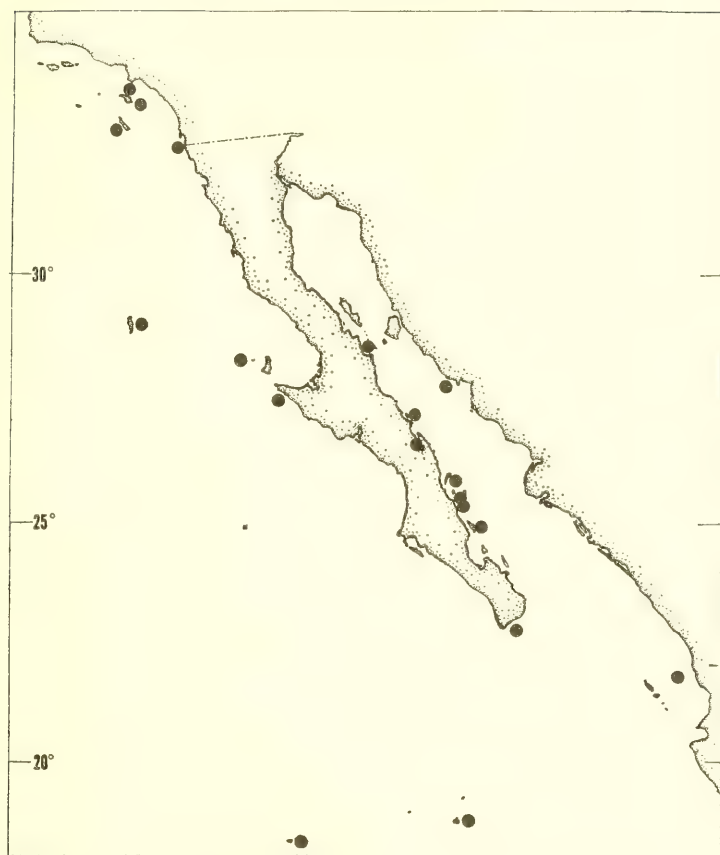


FIG. 34. Known distribution of *Eurydice caudata*. The southernmost record, La Libertad, Ecuador, is not included.

Ligia occidentalis Dana.—Mulaik, 1960: 95, pl. 2, fig. 20.—Brusca, 1973: 207–208, fig. 7.21.

Station 1–38, Cedros Island, Lower California, 17 July 1938, shore collecting north and south of cannery, east side of island: 150 specimens.

Distribution: From San Francisco Bay to Lower California and the Gulf of California. Brusca (1973) stated that it is probably the most common isopod in the intertidal zone of the Gulf of California. The southern limit is not known; specimens in the USNM from Tres Marias Islands, Mexico, may be the most southern record to date.

TRICHONISCIDAE

Trichorhina heterophthalma Lemos de Castro

Trichorhina heterophthalma Lemos de Castro, 1964: 1-7, figs. 1-2.

Station 14-38, Clipperton Island, 21 July 1938, from 2 booby nests on lagoon shore back of landing: 4 specimens, 2.7-3.2 mm.

For identification of these specimens I am grateful to Dr. George A. Schultz.

Distribution: Known only from the type-locality, Cueva Grande, Punta Caguanes, Yaguajay, Las Villas Province, Cuba (Lemos de Castro, 1964).

ONISCIDAE

Philoscia richardsonae Holmes and Gray

Philoscia richardsonae Holmes and Gray.—Mulaik, 1960: 158, pl. 11, figs. 217-223.

Station 1-38, Cedros Island, Lower California, 17 July 1938, from under drifted kelp on gravel beach to north: 35 specimens.

The above specimens were borrowed by Mulaik, who described and illustrated them in 1960. I have not seen them, since efforts to have them returned to Washington have been unsuccessful.

SCYPHACIDAE

Armadilloniscus holmesi Arcangeli

Armadilloniscus holmesi Arcangeli.—Mulaik, 1960: 135, pl. 6, figs. 93-105.—Schultz, 1972: 484, fig. 40 [synonymy].

Station 1-38, Cedros Island, Lower California, 17 July 1938, from under drifted kelp on gravel beach to north: 75 specimens.

The above specimens were borrowed by Mulaik and reported on by him in 1960. They have not yet been returned to the National Museum of Natural History.

Distribution: Friday Harbor, Washington, to Magdalena Bay, Lower California (Schultz, 1972).

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PROCEEDINGS
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THE ORIGIN OF THE HAWAIIAN MONK SEAL

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The Hawaiian monk seal, *Monachus schauinslandi*, is a remotely located, seldom seen, and possibly vanishing species (Kenyon, 1972). Clearly, it was derived from some Atlantic population (Ray, 1976b). Two other species are assigned to the genus: the Caribbean monk seal, *M. tropicalis*, that may not have been seen since 1952 (Kenyon, 1973) and the Mediterranean monk seal, *M. monachus*, whose future survival must also be considered doubtful (Ronald, 1973).

In 1956 Judith E. King published a monograph on these three modern species of the genus *Monachus*. Her description included the comparative skeletal anatomy of the Caribbean and Mediterranean monk seals but omitted a discussion of the postcranial skeleton of the Hawaiian monk seal as no specimen was available to her. In 1961 King and Harrison described the skeletal and other anatomy of a juvenile of the Hawaiian monk seal, the first entire individual of this species to become available at the British Museum (Natural History) and possibly at any major museum in the world, although a juvenile skeleton has been in the collections of the U.S. National Museum of Natural History since 1913, and an adult skeleton since 1923. The skeleton, particularly the postcranial skeleton of the Hawaiian monk seal, has in any case remained poorly known and has received very little published attention.

On the basis of the examination by very few people of very few specimens, it has been widely assumed that the three

modern species of *Monachus* are similar animals. Most authors have regarded *M. schauinslandi* and *M. tropicalis* to be especially similar or closely related (King, 1956, p. 229; Davies, 1958, p. 488) if not conspecific (Scheffer, 1958, p. 37), although Rice (1973, p. 99) considered *M. schauinslandi* and *M. monachus* to be the more closely related. Repenning (1972) used the ear region of the Hawaiian monk seal, because of the availability of specimens, as an example of a primitive condition in living seals. He presumed without further inquiry, because of the scarcity of the other two species, that the ear region of all species of *Monachus* represented a similarly primitive condition. The assumption was repeated in another report (Hendey and Repenning, 1972) in which the first well-known fossil monachine seal was compared to other fossil and living seals, and the conclusion was made that *Prionodelphis capensis* from Pliocene rocks of South Africa had an ear region more specialized than that of the living species of *Monachus*. However, actual comparison was made only with *M. schauinslandi*, the Hawaiian species.

Nevertheless, in their study of the juvenile specimen of the Hawaiian monk seal that was received by the British Museum (Natural History) in 1958, King and Harrison (1961) noted several unusual anatomical features. Most of these were found in the pattern of specialization of the posterior vena cava which was very different from that of any seal so far described and appeared to represent a stage of development that might have occurred during the evolution of the pinniped posterior vena cava from the conventional fissiped abdominal vein. These authors suggested that the observed conditions might be primitive. They further suggested that these conditions might indicate that "the [Hawaiian] monk seals are not able to dive for so long a period or as deep as" most living genera of pinnipeds except the California sea lion, *Zalophus*. In their exception they extended their comparison to an anatomically different group of pinnipeds, the otarioids, but they did include in their comparison most genera of the phocoid pinnipeds, the group to which *Monachus* belongs. These suggestions were repeated by King (1964, p. 118). King and Harrison (1961) also noted in the innominate bone a foramen for the

obturator nerve posterior to the condyloid notch of the acetabulum and anterior to the obturator fenestra. This foramen is not present in other species of *Monachus* or in other phocoid seals, although common in the otarioid pinnipeds. No conclusion was drawn from the presence of this feature.

In 1966 King published a detailed comparison primarily of the skeletal anatomy of the phocoid seals in order to explain her simplification of their taxonomic subdivision into only two subfamilies, the Phocinae and Monachinae. In this paper she noted that several features of the genus *Monachus* appeared to be less specialized than in other monachine seals, but she made no mention of the degree of primitiveness of the three living species of this genus relative to each other.

Thus, the first published statement since that of King and Harrison (1961, repeated in King, 1964, p. 118, and also inferred in Harrison and Kooyman, 1968, pp. 239-245) suggesting that the Hawaiian monk seal might, in some respects, be a uniquely primitive species of the genus *Monachus* was made by Ray (1976b), who also made note of the isolated foramen for the obturator nerve between the acetabulum and the obturator fenestra of the innominate bone. Ray further noted that in the Hawaiian monk seal the fibula was not fused proximally to the tibia, a distinctly fissiped character in carnivores and not known in skeletally mature individuals of any other pinniped except for primitive (fossil) otarioids and occasionally in living walrus (Repenning and Tedford, in press). The living walrus has been interpreted as retaining other features considered to be primitive (Repenning, 1976). The immaturity of the specimen examined by King and Harrison precluded any possibility that they could have detected the lack of fusion between the tibia and fibula in adulthood.

In 1976, while considering the biogeographic relations of fossil and living pinnipeds (Repenning, Ray, and Grigorescu, in press) we had occasion to note the osseous structures of the ear of *M. tropicalis*, the Caribbean monk seal. To our surprise they were much more specialized than those of the Hawaiian monk seal, *M. schauinslandi*. It thus became imperative to examine the osseous ear structures of the Mediterranean monk seal, *M. monachus*, and one of the very few skulls available

was dissected. From this it was obvious that the very primitive otic structures ascribed to the genus *Monachus* by Repenning (1972) and Hendey and Repenning (1972) applied primarily to the Hawaiian monk seal. Although slightly less specialized as here defined, the ear region of the Caribbean monk seal most resembles that of the Pliocene fossil from South Africa, *Prionodelphis capensis*, now also known, at least generically, from the Atlantic coast of the United States (Ray, 1976b). Although slightly less specialized as here defined, the ear of the Mediterranean monk seal appears to be fairly similar to that of *Monotherium? wymani*, a Miocene fossil monachine about 14.5 million years old (Ray, 1976a). Thus, although all modern species of *Monachus* do seem to be characterized by a primitive degree of ear specialization, the specialization of the ear of the Hawaiian monk seal is more primitive than that of any known living or extinct species of monachine seal and probably of any phocoid seal, although the different configuration of the phocine petrosal makes this last comparison more difficult to judge.

The ear region may thus be grouped with the relations of the tibia and fibula, the posterior part of the vena cava, and possibly the nature of the innominate bone as features of the living Hawaiian monk seal that appear to be primitive. The retention of such primitive features implies a very long period of isolation of the Hawaiian monk seal from related forms in the North Atlantic and the southern hemisphere, an isolation more ancient than *Monotherium? wymani*. Some paleobiogeographic considerations mentioned by Repenning, Ray, and Grigorescu (in press) favor such an ancient isolation of this particular species.

Materials: In the National Museum of Natural History there is a large collection of skulls and one adult and two juvenile skeletons of *Monachus tropicalis*, many skulls and some 16 skeletons (mostly juveniles) of *M. schauinslandi*, and one adult and one juvenile skeleton of *M. monachus* with skulls. In addition, in the comparative collection of the U.S. Geological Survey in Menlo Park, California, there are 6 partial skulls of *M. schauinslandi* and an additional skull of *M. monachus*; these specimens will eventually be catalogued in the

National Museum of Natural History and the U.S. Geological Survey numbers are temporary. For the purposes of this limited discussion, we have not attempted to review specimens in other institutions, although our observations have been supplemented from the literature.

Specimens or casts of all fossil phocids pertinent to this discussion have been available to us for examination, except for a few highly significant but unstudied specimens from Peru under the care of Robert Hoffstetter, Muséum National d'Histoire Naturelle, Paris. These were mentioned briefly by Hoffstetter (1968). According to Hoffstetter's correspondence (to Repenning, 1973) these phocid fossil remains of late Miocene or early Pliocene age include a tibia and fibula that are unfused, although he made no mention of their maturity. If the specimens are from mature individuals, they represent the only known occurrence of this feature in phocoid seals except for the living Hawaiian monk seal.

THE EAR

Although individually variable in detail and difficult to evaluate functionally, the pinniped ear shows evidence of the adaptation of a carnivore to the marine environment no less conspicuous or remarkable than the evolution of flippers from paws. The adaptation is basically a marine one, as shallow-water aquatic carnivores have little or no modification of the functional ear, but the adaptation is one for which selective forces have strong and immediate influence once a carnivore begins deep-water feeding.

Two factors are involved (Repenning, 1972): protection against hydrostatic pressure, which has a relatively immediate effect upon the ear structure of developing marine carnivores, and directional sensitivity to hearing in water, which has a selective force that is not so strong or immediate, at least as indicated in the fossil record of otarioid pinnipeds (Repenning, 1976). The ability to withstand prolonged apnea, hence the ability to make longer dives, also developed gradually in the otarioid pinnipeds, and, hence, presumably in the phocoid seals (Repenning, 1976).

From their observations of the structure of the posterior vena

cava of the Hawaiian monk seal, King and Harrison (1961), as noted above, suggested that this species may not be able to dive as deep or as long as other phocoid seals. They suggest that this may represent the persistence of an embryonic or primitive condition.

Similarly, the ear of the Hawaiian monk seal shows some indication of primitive deep diving adaptation. The osseous structure of the ear and the adjacent structures of the temporal bone appear to be well adapted to protection against hydrostatic pressure. Nevertheless, the cavernous tissue lining the middle ear, which inflates with blood to prevent development of a relative vacuum as ambient pressure increases, is distributed in the region of the epitympanic recess in a pattern quite unlike that of the other monachine and phocine seals (Repenning, 1972, pp. 315, 322). This pattern appears to parallel that of the otarioid pinnipeds, although at the present level of understanding such a parallelism seems as inexplicable as does the presence of a distinct obturator foramen widely separated from the obturator fenestra of the innominate bone, a feature common also in the otarioid pinnipeds. We are inclined to believe that both reflect some unknown primitive condition, as the separation of tibia and fibula reflects a known primitive condition.

In the case of the cavernous tissue in the middle ear of the Hawaiian monk seal, the unusual distribution of the tissue suggests considerable adaptive evolution independent from that shown in other phocoid seals. It should be noted, however, that the distributional pattern of this tissue in the middle ear of the Caribbean and Mediterranean monk seals is unknown and is likely to remain so.

One phocoid feature that appears to be directly related to more sensitive hearing in water is quite weakly developed in the Hawaiian monk seal, less so than in any known fossil or living phocoid seal. This is the enlargement of the dorsal part of the petrosium (Pl. 1).

Along the medial side of the phocoid petrosium an upper and lower part may be defined by a line extending from the vestibular aqueduct forward across the top of the cochlear aqueduct to the anterodorsal surface of the apex. In many mona-

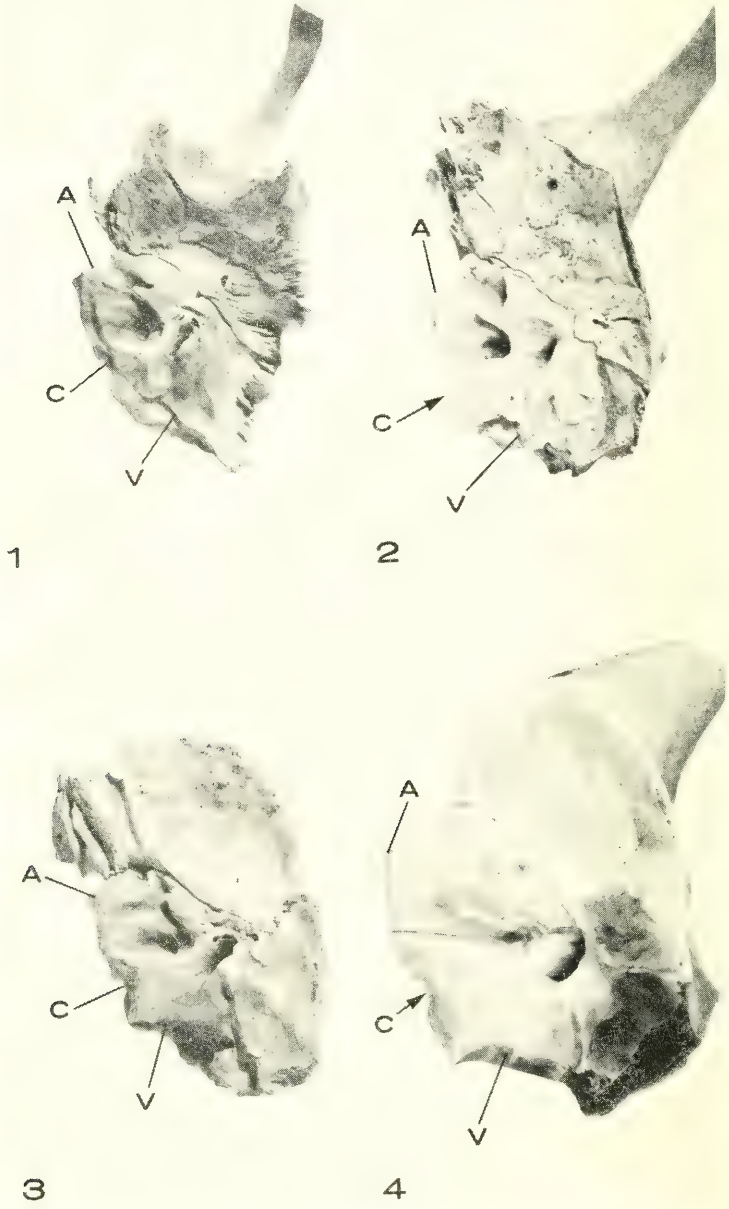
chines, including all species of *Monachus*, it is marked by a groove that lies parallel to and slightly above the ventral petrosal sinus occupying the petrobasilar trench; in other monachines, as *Leptonychotes*, the groove is obliterated by pachyostosis of the petrosium.

As seen in Plate 1, the dorsal part of the petrosium in *M. schauin landi*, as defined above, is smaller than the ventral part which protrudes medially and apically from beneath the dorsal part. In *M. tropicalis*, in dorsal view, the dorsal part conceals the ventral part in all areas except those most postero-medial and most apical; in addition the dorsal part is somewhat more massive. In *Prionodelphis capensis*, the fossil seal from South Africa (Hendey and Repenning, 1972), the postero-medial area of the ventral part is mostly concealed (a small spur of the dorsal part is broken off of the illustrated specimen in this area) and the dorsal part of the petrosium is even more robust, particularly at its apex. In the living *Leptonychotes weddelli*, these modifications have reached their extreme.

Primary attachment of the petrosium to the mastoid part of the temporal is via the ventral part of the petrosium, which houses the cochlea, and thus progressive enlargement (especially apically) of the dorsal part, which houses the semicircular canals, increases the mass of the petrosium on the side of the cochlea opposite to that of the primary attachment to the mastoid. This progression is interpreted as reflecting increasing sensitivity to waterborne sound, although it has no inferable relationship to sensitivity toward the direction of sound (Repenning, 1972).

Enlargement of the dorsal part of the petrosium is at least as great in *M. monachus* as in *M. tropicalis* and the degree of development of this specialization is least, among all living phocoid seals, in *M. schauinslandi*. In addition, the specialization of the dorsal part of the petrosium of *M. schauinslandi* is less than that of any known fossil phocoid seal, including the 14.5-million-year-old *Monotherium? wymani* from Virginia (Ray, 1976a).

In ventral aspect (Pl. 2) the lower part of the petrosium, as here defined, is very similar in *M. schauinslandi* and *M. tropicalis* except that it is somewhat more robust in *M. tropicalis*



and the promontorium, largely formed by the basal whorl of the cochlea, is somewhat larger and has a slight secondary swelling anteromedial to the oval window and anterior to the round window in the Caribbean species. This slight secondary swelling of the promontorium indicates a relative enlargement of the apical whorls of the cochlea which is even more conspicuous on the petrosus of *M. monachus*. On the other hand, there is no tendency for such enlargement on the promontorium of *Leptonychotes weddelli* but, instead, it is characterized only by great exaggeration of the basal cochlear whorl.

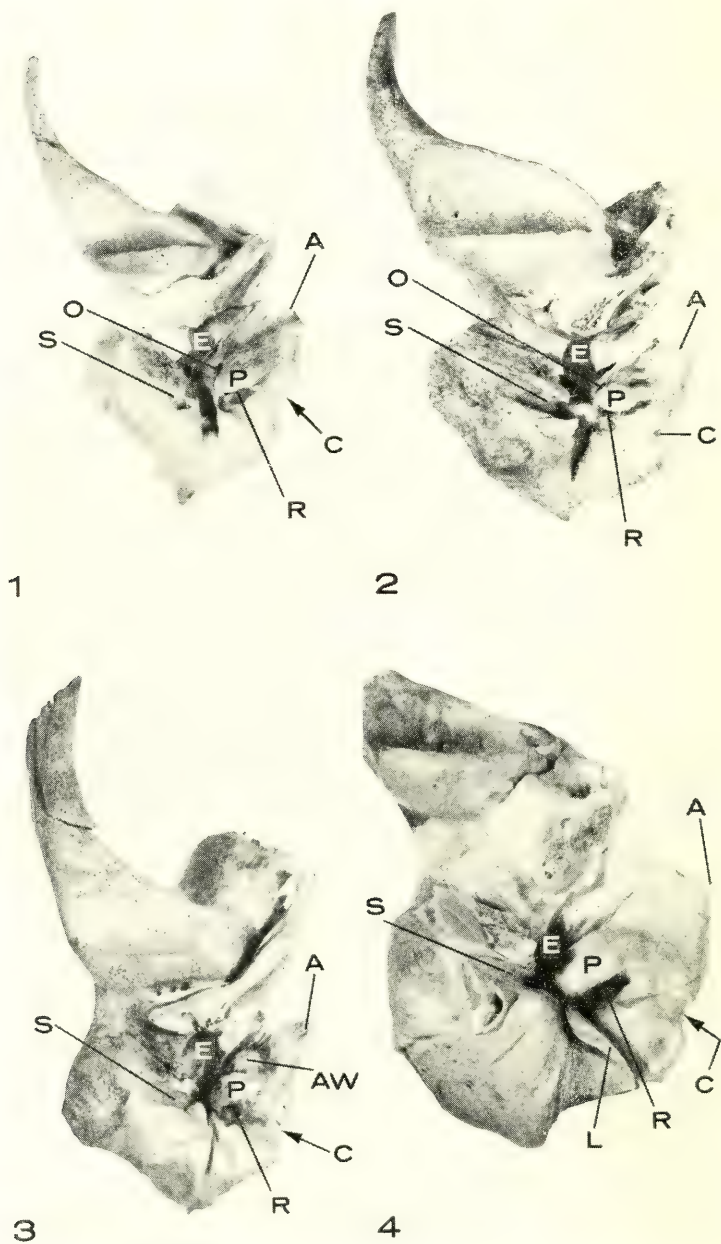
Although enlargement of the entire cochlea may well indicate greater sensitivity in hearing, enlargement of the basal whorl only has been interpreted as reflecting increased sensitivity toward the direction of sound in water; it is the pattern followed by most phocoid seals (Repenning, 1972).

Thus, with respect to the structure of the cochlea, it appears that the living *Monachus schauinslandi* is the most primitive of known phocoid seals, although fewer fossils are available for comparison because the tympanic bullae are typically preserved in place on the temporal bone of fossil seals. From the condition of the promontorium of *M. schauinslandi* increasing specialization could have followed a pattern of increasing sensitivity, as shown primarily by *M. monachus*, or a pattern of increasing sensitivity only in that part of the cochlea most significant to directional hearing, as shown in most living phocoids.

The ventral part of the petrosus of the fossil species, *Prionodelphis capensis*, appears, as does the dorsal part, to be intermediate between living *M. tropicalis* and *Leptonychotes weddelli*. Not only is the medial lip of the dorsal part extended

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PLATE 1. Dorsomedial views of the right temporal bones of (1) *Monachus schauinslandi*, (2) *M. tropicalis*, (3) *Prionodelphis capensis*, and (4) *Leptonychotes weddelli* showing relative differences in size of the dorsal part of the petrosus. V = vestibular aqueduct, C = cochlear aqueduct, A = apex. Tympanic bullae have been removed except part remains on the fossil specimen of *P. capensis*. Anterior is up. Approximately $\times \frac{3}{4}$.



beyond the medial lip of the ventral part and the promontorium greatly swollen by enlargement only of the basal whorl of the cochlea, but also a conspicuous lip of the mastoid has developed which overlaps the posterior wall of the tympanic bulla (Pl. 3, figs. 1 and 2). Not unexpectedly, the ear region of this fossil species appears to be more specialized than do those of the living Caribbean and Hawaiian monk seals, and in all features reflecting such specialization *M. schauinslandi* from Hawaii appears to be extremely primitive. Moreover, the fossil *P. capensis*, on the basis of these similarities, seems to be only remotely related to the Mediterranean monk seal, as it appears to have different specializations in its ear relative to the part of the cochlea emphasized.

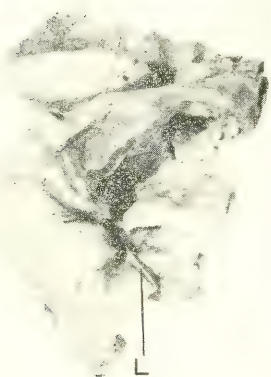
No conclusion is drawn from the auditory ossicles except that they show considerable interspecific differences. Upon gross examination, the head of the incus of *M. tropicalis* appears to be relatively the least developed and the incudo-malleolar articulations form a single confluent saddle-shaped articulation as described by King (1969, p. 12), and confirmed on additional specimens by Ray (1976a, p. 18), for *Ommatophoca*; the first would suggest minimal specialization and the latter great specialization.

POSTCRANIAL SKELETAL PECULIARITIES

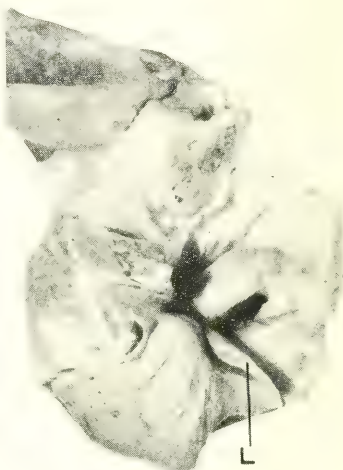
King and Harrison (1961, fig. 4a) and Ray (1976b, fig. 4) have noted and illustrated the presence of a separate foramen for the obturator nerve midway between the acetabulum and

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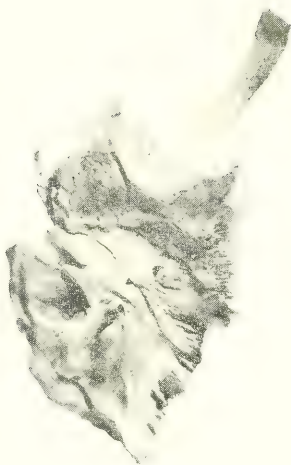
PLATE 2. Slightly lateral of ventral views of the temporal bones of (1) *Monachus schauinslandi*, (2) *M. tropicalis*, (3) *M. monachus*, and (4) *Leptonychotes weddelli* showing differences in form of the promontorium of the petrosus related to variations in specialization of the cochlea. A = apex, C = cochlear aqueduct, P = promontorium, O = oval window [hidden in (3) and (4)], R = round window, E = epitympanic recess, S = stylomastoid foramen, L = lip of the mastoid on *Leptonychotes* that overlaps the posterior part of the bulla, and AW = secondary swelling of the promontorium of *M. monachus* that houses apical whorls of the cochlea. Tympanic bullae have been removed and anterior is up. Approximately $\times \frac{3}{4}$.



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the obturator fenestra in the innominate bone of the Hawaiian monk seal. This foramen is present on both sides in all individuals of *M. schauinslandi* in the National Museum of Natural History. It is of large caliber, 5 mm or more in many instances; fully developed even in newborn individuals; confined to the pubis, or in at least one case bordering the anterior pubo-ischiadic suture; and penetrates the thick body of the bone, generally closer to the acetabulum than to the obturator fenestra. Although a similar foramen is variably present in living otarioid pinnipeds, most commonly in the fur seals, *Arctocephalus* and *Callorhinus*, we are aware of its occurrence in no other living or fossil phocoid, including the early phocine forms, *Leptophoca lenis*, for which several innominate bones are available, and *Phoca vindobonensis*. Unfortunately, the innominate bone is unknown for *Monotherium?* *wymani*, the oldest monachine.

Some individuals of some species of modern phocoids have a more or less strongly marked notch or channel at the anterior extremity of the obturator fenestra, probably homologous to the obturator foramen of *M. schauinslandi*. This channel seems to be especially well marked in some individuals of *Cystophora*, for example. We have noted closure of the notch unilaterally by a narrow, thin bridge of bone in one specimen of *Hydrurga* and in two of *Phoca vitulina* among the many phocoid skeletons available to us, including at least one of every living species. These foramina however are scarcely comparable to those in *M. schauinslandi* in that they are uncommon, unilateral, and marginal to the obturator fenestra, from which they are only weakly separated apparently late in life. Interestingly, of innominate bones of two adult individ-

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PLATE 3. Ventral views of the temporal bones of (1) *Prionodelphis capensis* and (2) *Leptonychotes weddelli*. L = lip of mastoid that overlaps posterior wall of bulla. Anterior is up. Dorsal views of the temporal bones of (3) *Monachus schauinslandi* and (4) the 14.5-m.y.-old *Monotherium?* *wymani* to show relative enlargement of the dorsal part of the petrosus. The photograph of the temporal bone of *Monotherium?* *wymani* is taken from Ray (1976a) and is shown at natural size; all other photographs are approximately $\times \frac{3}{4}$.

uals of *M. tropicalis* illustrated by Allen (1887, Pl. 4, figs. 4 and 5), one shows a well marked notch and the other a fully closed foramen. In the one old adult skeleton of *M. tropicalis* available to us, a foramen is almost completed in the left innominate bone only, by thin projections of bone separated by a very narrow gap. The foramen, as strongly developed and uniformly present in *M. schauinslandi* at least from birth, seems to us to be a primitive feature unique to that species among known fossil and modern phocoid seals.

Ray (1976b, fig. 5) has also noted that all available skeletons of the Hawaiian monk seal have the proximal epiphysial head of the fibula unfused to the epiphysial head of the tibia; in individuals mature enough to evaluate (at least 6 in the National Museum collections), distinct articular facets are present at contiguous points of these two bones. Except occasionally on one or both sides in living walrus (interpreted by Repenning, 1976, as retaining other primitive features), this condition also is unknown in living pinnipeds and is unknown, with one possible exception, in all fossil phocoid seals including *Monotherium? wymani* (Ray, 1976a) and *Leptophoca lenis*. However, Repenning and Tedford (in press) report this condition in early otariid otarioid pinnipeds, forms probably between 7 and 8 million years old. Work we have in progress indicates that pinnipeds ancestral to the otariids were characterized by separate tibia and fibula, which is understandable as they were derived from fissiped carnivores (Mitchell and Tedford, 1972).

Although she stated that the two bones are fused proximally as usual in pinnipeds, King (1956, pp. 241, 250) did note that in only one of two adult skeletons of *M. monachus* was the fibula fused to the tibia, and in that instance only on one side. She suggested that this fusion must be among the last to occur. In the one adult *M. monachus* available to us the tibia and fibula are fused proximally on both sides. We are somewhat uncertain as to whether or in which instances King's statements apply to coossification between the proximal epiphyses of the tibia and fibula or to fusion of each epiphysis with its diaphysis, but in any event, we regard the coossification between tibia and fibula as typical of adult *M. monachus*, pending examination of more specimens. In species in which proximal coossifi-

cation occurs with age, the condition may be anticipated in younger animals by the sutural contact between the two elements, rather than by a faceted contact as in *M. schauinslandi*. Further, in these species the proximal epiphyses typically coossify with one another before either fuses with its respective diaphysis.

The one apparent example mentioned above in the fossil record of phocoids in which the tibia and fibula remain separate is an undescribed record from Sacaco, Peru, briefly mentioned by Hoffstetter (1968). In correspondence (to Repenning, 1973) Hoffstetter has stated that the phocoid seal from Sacaco has an unfused tibia and fibula and is broadly estimated as being late Miocene or early Pliocene in age, or about 5 million years old. The maturity of the individual was not mentioned. Although undescribed and certainly vague in details, this could well be a highly significant record.

Should the Peruvian fossil be from an adult, it would suggest that this seal belonged to a population which, like the ancestor of the Hawaiian monk seal, became separated from the Atlantic-Caribbean monachines at a very early date (perhaps 15 million years ago) and could, therefore, indicate a much more ancient separation of the antarctic monachines from the ancestral monachines of the North Atlantic than presently supposed. The fossil phocoids from Peru are associated with fossil otarioids (Hoffstetter, personal commun., 1973) and are the oldest (some 5 million years) recorded pinnipeds in the southern hemisphere. However, the remarkably abundant remains of *Prionodelphis capensis* from South Africa may be little more than a million years younger and no otarioid remains are known in this area; the oldest fossil otarioid known from South Africa (Hendey, 1974) is much less than one million years old. Possibly, as suggested by Repenning, Ray, and Grigorescu (in press), the Peruvian fossils do not represent the oldest phocoid in the southern hemisphere.

POSTERIOR VENA CAVA

Elsner (1969, pp. 138-140) has summarized the differences between the posterior venae cavae of the pinnipeds and those of terrestrial mammals, and he has outlined his experimentation

showing that these pinniped modifications of the basic mammalian pattern enable the storage of a great quantity of well-oxygenated blood which, in turn, enables the seal to prolong greatly its time of apnea during dives. Harrison and Kooyman (1968, pp. 239–247) summarize in more detail the anatomy of the pinniped venous system and outline the differences between the abdominal veins of otarioid and phocoid pinnipeds. In this discussion they frequently refer to the work of King and Harrison (1961) on the Hawaiian monk seal, pointing out how it differs from the general phocoid pattern.

In fissiped carnivores the posterior vena cava is of conventional mammalian pattern beginning with the union of the common iliac veins and running anteriorly as a single trunk to the diaphragm. The principal tributaries are the left and right renal veins, the left being somewhat more elongate and complicated because of secondary tributaries, and, more anteriorly, the hepatic veins. In most phocoid seals the posterior vena cava is bifurcate in and posterior to the region of the renal tributaries, which are multiple to accomodate the circulatory specialization of the kidneys. Anterior to the renal tributaries the right and left branches of the postcava unite to form a single large trunk running forward to the region of the hepatic veins where it is greatly inflated into a hepatic sinus. The hepatic sinus and the large and distensible posterior vena cava, including left and right branches, can store a great volume of blood relative to the size of the animal. Elsner and others (1964) indicate that the posterior vena cava of the northern elephant seal is capable of holding about one fifth of the total body blood.

In addition to the spectacular storage capacity of the phocoid posterior vena cava, it contains, at the diaphragm, a sphincter that regulates the flow of stored blood to the heart during diving (Hol, Blix, and Myhre, 1975).

In all of these phocoid specializations, the exception is the Hawaiian monk seal. King and Harrison (1961) described the posterior vena cava as being duplicated, but, in the region of the renal tributaries there is a complex network of anastomotic channels, and some renal tributaries join the postcava anterior to the principal bifurcation. The hepatic sinus is only slightly

inflated and still retains falciform septa, relics of the walls of those parts of the hepatic veins that have become incorporated in the sinus, and the sphincter at the diaphragm is incomplete.

From their illustration (King and Harrison, 1961, p. 290) it would appear that the right branch of the postcava is the original trunk of the fissiped posterior vena cava and that the left branch probably developed from the left renal vein of the fissipeds. A similar interpretation was made of the posterior vena cava of *M. monachus* in 1927 by Dieuzeide; however, he described no complex network of anastomoses. The network of anastomotic channels noted by King and Harrison certainly looks like drainages from the stellate renal plexus of the left kidney that are relics of a still more primitive marine phocoid that retained a fissiped-like, unbranching posterior vena cava with an unenlarged left renal vein.

There is, of course, no fossil record of the development of the distinctly phocid pattern of the posterior vena cava. However, as with other specializations described above, the relatively undeveloped specializations of the posterior vena cava of the Hawaiian monk seal that set it apart from other phocoid seals resemble the condition found in the otarioid pinnipeds, as pointed out by King and Harrison (1961) and Harrison and Kooyman (1968).

Whether these features of the Hawaiian monk seal that we have discussed represent parallel specializations or retained primitive features may not be clear in all cases, but certainly they all suggest that *M. schauinslandi* may well be regarded as the most primitive of living seals.

BIOGEOGRAPHIC CONSIDERATIONS AND CONCLUSIONS

Repenning, Ray, and Grigorescu (in press) discuss at some length the biogeographic significance of the available distributional and evolutionary history of the pinnipeds including that of *Monachus schauinslandi* in the Hawaiian Islands. They conclude that this seal was derived from the North Atlantic, probably from a Caribbean population, both because of the nature of the North Atlantic fossil record and because of the

existence of a Central American seaway separating North and South America.

The available evidence suggests that the Hawaiian monk seal may have been separated from its ancestral population more than 15 million years ago. The unspecialized features of the Hawaiian monk seal discussed above are more primitive than those of the oldest known fossil monachine seal, approximately 14.5 million years old. This date correlates with the maximum in oceanic temperatures 15 million years ago, thus favoring a Caribbean seal crossing half the Pacific Ocean, and also approximates the most recent time that the full force of the Atlantic equatorial currents passed between North and South America and joined the Pacific North Equatorial Current, thus assisting the westward dispersal with both current and temperature. Finally, the known tectonic-volcanic history of the Hawaiian Island chain indicates that there were at least some islands present to colonize.

The Hawaiian monk seal, therefore, appears to be the modern representative of the most ancient of living phocoid lineages, and as such might be characterized not altogether improperly as a "living fossil". Of all living pinnipeds only the walrus approaches such a genealogical distinction, but available fossil evidence seems to indicate that its lineage, which includes many extinct forms, probably began somewhat more recently (Repenning and Tedford, in press). The several uniquely primitive anatomical features of the Hawaiian monk seal and its very poorly known anatomy and virtually unknown behavioral and adaptive characteristics suggest that much insight into pinniped natural history might be gained from its study. The opportunity for such a study of its closest relatives has almost certainly been lost irrevocably in the case of *M. tropicalis* from the Caribbean and probably most of the social characters of *M. monachus* have already been drastically altered through human intervention. Without immediate attention the anatomy and physiology of the Mediterranean monk seal will also remain forever virtually unknown.

The survival of the Hawaiian monk seal is not at all ensured. It is a unique mammal, thorough understanding of which might well improve our understanding of all seals. Obviously

a better understanding of *Monachus schauinslandi* would enhance its chances for survival. If it is justifiable to make distinctions in the relative importance of species, then *M. schauinslandi* has to be assigned high priority. Therefore we are encouraged to recommend that comprehensive, careful, and sustained studies of the Hawaiian monk seal be carried out very soon.

ACKNOWLEDGMENTS

After many years of interest in pinnipeds, it is difficult to judge who among many colleagues has contributed most substantially to whatever understanding we have developed, but most especially for monachines the contributions of Judith King are the foundation for all analysis. Francis Fay and Richard Tedford have always shared their broad knowledge of pinnipeds and fissipeds, and in the present context have reviewed a draft of the manuscript and contributed materially to its improvement. With respect to essential fossil material for study, Peter J. Harmatuk of Bridgeton, North Carolina, stands alone as the most productive collector of phocid specimens in North America, and Q. Brett Hendey of the South African Museum has been more than generous in permitting us to study and describe specimens of *Prionodelphis capensis* in his collection.

The photographs, except that in plate 3, figure 4, were made by Kenji Sakamoto, and the plates prepared in part by Lawrence B. Isham. Financial support was provided in part through the Smithsonian Research Foundation.

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PROCEEDINGS
OF THE
BIOLOGICAL SOCIETY OF WASHINGTON

THE SYSTEMATIC POSITION OF THE MILLIPED
FAMILY APTEROURIDAE (DIPLOPODA,
CHORDEUMIDA, STRIARIOIDEA) AND A
REDESCRIPTION OF *APTEROURUS HORIZONTALIS*
LOOMIS¹

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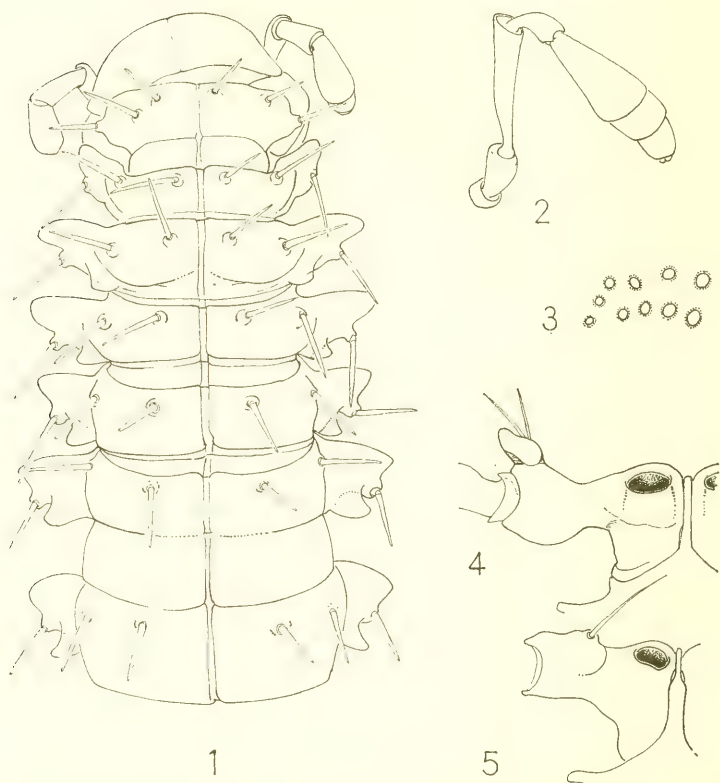
The milliped family Apterouridae and its single included species, *Apterourus horizontalis*, were described by Loomis (1966) from specimens collected by O. F. Cook in 1929 at Cajon Pass in California. The description unfortunately contained errors, particularly with regard to the structure of the gonopods, and only sketchy figures were presented. The types were evidently misplaced for several years, so that in my monograph of the American chordeumids (Shear, 1972) I was unable to study them and unable to place the family in the larger system. I was finally able to borrow the types through the cooperation of Dr. Ralph Crabill of the National Museum. The retention of *A. horizontalis* in its own monobasic family seems justified at this time in view of its relationships and its unusual combination of primitive and highly evolved characters. The family belongs in the superfamily *Striarioidea*, as defined by me in 1972.

Apterourus horizontalis Loomis
Figures 1-8

Apterourus horizontalis Loomis, 1966:223, figs. 1-4.

Types: Male holotype, male, female and juvenile paratypes from Cajon

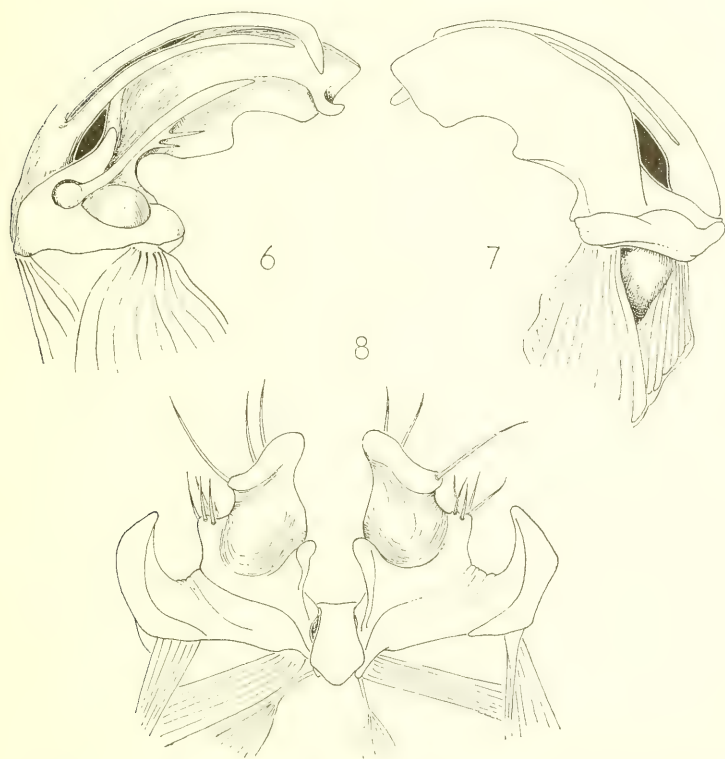
¹ Research supported by a grant to the author from the Mednick Fund, through the Virginia Association of Independent Colleges.



FIGS. 1-5. Anatomy of *Apterourus horizontalis*. 1. Head and anterior seven segments of male. 2. Antenna of male. 3. Left eyepatch of female (anterior to the left). 4. Coxae 10 of male, ventroposterior view. 5. Coxae 11 of male, ventroposterior view.

Pass, 7 miles west of Cajon on Big Pine Road, San Bernardino Co., California, collected 14 February 1929 by O. F. Cook, deposited in USNM (myriapod collection No. 3159), examined.

Description: Male holotype and male paratype with body form as described by Loomis (1966), the following features of particular importance. About 7 mm long. Collum (fig. 1) convex, posterior margin incurved, outermost seta on short prominence, collum partly covering head. Segments (fig. 1) nearly circular in cross section, with flaring, broad, thin, winglike paranota projecting from lateral midpoints. Paranota at first angled forward, but more posterior ones projecting straight



FIGS. 6-8. Anatomy of *Apterourus horizontalis*. 6. Left anterior gonopod, mesial view. 7. Same, lateral view. 8. Posterior gonopods (legpair 9), anterior view.

laterad, two-lobed; outer lobe thick, anteriorly somewhat rimmed, bearing outermost segmental seta midway on its posterior margin; inner lobe projecting from near posterior base of outer lobe, thin, translucent, absent from second segment, becoming prominent on more posterior segments. Paranota reduced in size from segment 7 to segment 24, absent from segments 25-30. Mentum of gnathochilarium divided, antennae (fig. 2) strongly clavate. Eyes much reduced, 4-5 unpigmented ocelli hardly detectable in male. Legs 3-7 crassate, declining in size from anterior to posterior, legpair 3 largest, prefemur slightly swollen and with slight posterior depression.

Gonopods (figs. 6,7) in socket with high lateral rims, closely appressed in midline, sternum more or less completely divided. In lateral view

(fig. 7), lateralmost coxite broad, flat, evenly curved, narrowed at base, only partially concealing divided flagelliform mesal coxite. Lateral sternal sclerite smooth, heavily chitinized. In mesal view (fig. 6) lateral coxite with mesial ridge bearing two short, pointed branches basally and large blunt hook distally, otherwise thin. Mesial coxite with two evenly curved flagelliform branches. Articulated coxal flagellum located near mesial posterior base of coxal region; telopodite reduced to small, low, rounded swelling.

Posterior gonopods developed from ninth legs (fig. 8). Sternum complete, with large flared regions laterally; coxae immovable, fused to sternum, articulating in midline with knoblike sternal sclerite. Teleopodites lobed and setose, anteriorly concave, as shown.

Coxae of legpair 10 (fig. 4) enlarged, with gland, and mesioapical knob bearing two strong setae; coxae 11 somewhat similar but not so strongly modified (fig. 5).

Female: Similar in nonsexual characters to male described above, but body somewhat more robust. Eyes as in fig. 3. Cyphopods large, protruding, possibly permanently extended, posterior margin of cyphopod socket formed from sternite of segment 3.

Distribution: Known only from the type-locality.

Discussion: Loomis (1966) failed to dissect either of the males available to him thoroughly enough to find the ninth legs, thus he erroneously stated that the gonopods were formed from the eighth legs and that the ninth legs were essentially similar to those that followed. Under the family description, Loomis wrote that the "eleventh" coxae were "perforate," a statement which is not consistent with his interpretation of the gonopods, since if the tenth legs were thought by him to be the ninth, the "eleventh" legs he described should actually have been the twelfth, which do not bear a coxal gland. No mention is made of a gland opening on the coxae of the "tenth" (actual eleventh) legs, nor on the "ninth" (actual tenth) legs. In fact, both the tenth and eleventh pairs of legs have coxal glands. Loomis missed the real ninth legs entirely since they are usually reduced and completely concealed in situ by the anterior gonopods. This misinterpretation of the gonopods was what made the Apterouridae impossible to place in the larger picture of the Order Chordeumida, without examining specimens.

The gonopod anatomy clearly links this family to the Striariidae, Urochordeumidae, Rhiscosomididae and Caseyidae, which, taken together, make up the superfamily Striarioidea (Shear, 1972). Members of the superfamily have a divided mentum, 30 segments, and gonopods with two or more coxites, one of which is frequently movable, and flagelliform. The posterior gonopods (ninth legs) are generally reduced but retain in most species at least one separate telopodite segment; the tenth legs bear coxal glands. While agreeing with the other families in most ways, there are some differences in *A. horizontalis*. The eleventh coxae have gland openings, suggesting the Superfamily Brannerioidea, a related but

perhaps more primitive group; Loomis (1966) indirectly suggested membership in the Brannerioidea by relating the Apterouridae to the Tinguipidae. Other members of the superfamily Striarioidea also have a rather prominent, lobelike gonopod telopodite, while in *Aperourus horizontalis* the gonopod telopodite is very much reduced and appears only as a smooth mound on the posterior surface of the gonopod. The ninth legs are also very much reduced, with the coxae fused to the sternum.

These differences are not of sufficient importance to place *A. horizontalis* outside the Superfamily Striarioidea, since all of them simply represent stages in reduction of various characters which are duplicated in kind in other superfamilies of millipeds.

Among the other families in Striarioidea, Apterouridae seem closest to another monobasic, little known family, Urochordeumidae, which it resembles in gonopod plan and body form. However, urochordeumid species are much larger, have far more prominent, flat paranota, giving an almost polydesmoid appearance, and have an extensive suite of pregonopodal leg modifications not found in *Apterourus*. The most primitive known chordeumids are the Heterochordeumatidae of Southeast Asia (Hoffman, 1963). Members of this family have broad paranota and are very much like platydesmids in general form. The gonopods are leglike, not strongly modified. Taking this as evidence it is likely that the primitive body form in the Chordeumida was flat, with prominent paranota. Among the Striarioidea, the Urochordeumidae have a flat body with broad paranota and therefore may be the most primitive of this subfamily. The Apterouridae and Rhiscosomididae have segments that are rounder in cross section but retain paranota—much broader in the Rhiscosomididae. In the Striariidae, the paranota are reduced and the body is heavily armored for burrowing, while the Caseyidae have lost all trace of paranota and are quite cylindrical. Paranota are probably an adaptation for forcing a way between layers of leaf litter, while the cylindrical body form gives extra power and protection for burrowing.

Thus the Order Chordeumida may have originated as a group of leaf-litter dwelling species which later radiated to other habitats, including those which required a body form adapted to burrowing. The trend has been reversed in a few species of Cleidogonidae, most Conotylidae and in Trichopetalidae, in which relatively large "paranota" have been formed from the basal tubercles of the segmental setae. These secondary developments are not thin and platelike and bear the segmental setae in different positions than in the Striarioidea.

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PROCEEDINGS
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DENDROSOMIDES LUCICUTIAE, A NEW SPECIES
OF SUCTORIAN FROM THE PELAGIC CALANOID
COPEPOD, *LUCICUTIA*

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While enumerating the copepods in plankton samples collected by M/V THEODORE N. GILL off the southeastern United States (Bowman, 1971), I noticed a striking suctorian attached to the urosome of *Lucicutia gaussae*. During subsequent counts of copepod species I removed all specimens of *Lucicutia* carrying this suctorian, and obtained 18 copepods from 14 stations carrying a total of 40 suctorians. Two more infested specimens of *Lucicutia* from NE of the Madeira Islands collected by M/V PILLSBURY brought the total to 43 suctorians from 21 copepod hosts. Sixteen of the hosts were *Lucicutia gaussae* and 4 were *L. flavicornis*, a much more abundant species.

These suctorians are herein assigned to a new species of *Dendrosomides*, the 6th of the genus. The classification followed below is that recently proposed by Batisse (1975a, 1975b).

Superorder SUCTORIDEA Clarapède & Lachmann, 1858
Order SUCTORIDA Clarapède & Lachmann, 1858
Suborder OPHRYODENDRINA Batisse 1975a
Family RHABDOPHRYIDAE Jankowski, 1967
Dendrosomides Collin, 1906

Dendrosomides lucicutiae, new species

Figures 1-2

Material examined: From the calanoid copepods, *Lucicutia gaussae* Grice and *L. flavicornis* (Claus), attached to the last pediger, the uro-

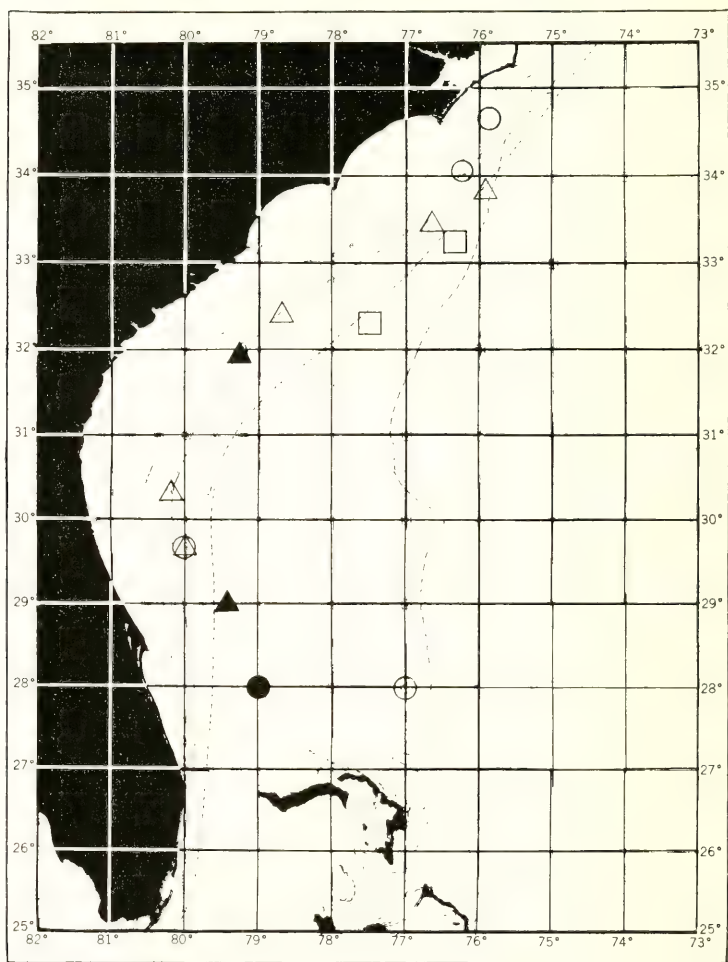


FIG. 1. Occurrence of *Dendrosomides lucicutiae* on T. N. GILL cruises 2 (circles), 3 (triangles), and 4 (squares). Open symbols, on *Lucicutia gaussae*; solid symbols, on *L. flavicornis*.

somites, caudal rami, caudal setae, or male 5th legs. Copepods were collected off the southeastern United States between Cape Hatteras and Cape Canaveral during Cruises 2 (16 April–15 May), 3 (16 July–12 August) and 4 (5 October–14 November) of M/V Theodore N. Gill in 1953. Collections were made with a half meter silk or Monel metal (Gulf III) net towed obliquely from about 70 m to the surface (Bow-

TABLE 1. Occurrences and position on host of *Dendrosomides lucicutiae*.

T. N. GILL Cruise		Sex of Copepod	Pediger 4-5	Leg 5	Location on Copepod				Caudal ramus	Caudal seta
					Urosomite					
					1	2	3	4		
2	18	♀							2	1
	71	♀							1	1
	75	♀	1							1
		♂		1	1					
	Spec. 7	♀							1	
	Spec. 9	♂ *				5	3			
	3	16	♀ *					1		
		26	♀							1
		42	♀							2
		48	♀ *						2	
3		♀								1
		64	♀				1			1
			♀					1	1	
		72	♂		1					
	4	18	♀	1						
		51	♀					1	1	
			♀		1		1	1	1	1
		63	♀					1	1	
			♀					1		
	NE of Madeira									
Is.		♀								1
		♀ *							1	
Totals			2	3	1	5	5	6	11	10

* *Lucicutia flavicornis*. All others are *L. gaussae*.

man, 1971). The localities where *Dendrosomides lucicutiae* was found on *Lucicutia* are shown in Fig. 1.

Type-material: Holotype, USNM 24412, dendritic individual attached dorsally to next-to-innermost caudal seta of right caudal ramus of female *Lucicutia gaussae* Grice (Fig. 2A); T. N. Gill Cruise 4, station 51, in Gulf Stream east of Beaufort, South Carolina, 32°18'N, 77°29'W; depth 643 m; 26 October 1953. The remaining 42 specimens, listed in Table 1, are paratypes. All specimens are deposited in the Ciliate Type-Specimen Collection of the Department of Invertebrate Zoology, National Museum of Natural History, Smithsonian Institution.

Etymology: Named for the host copepod genus, *Lucicutia*.

Description: Stalk of dendritic specimens short to moderately long, of nearly uniform width, with very faint longitudinal striations visible in stained specimens. Body with shape of flattened vase, branching distally into 4-8 long slender arms bearing circles of knobbed tentacles at

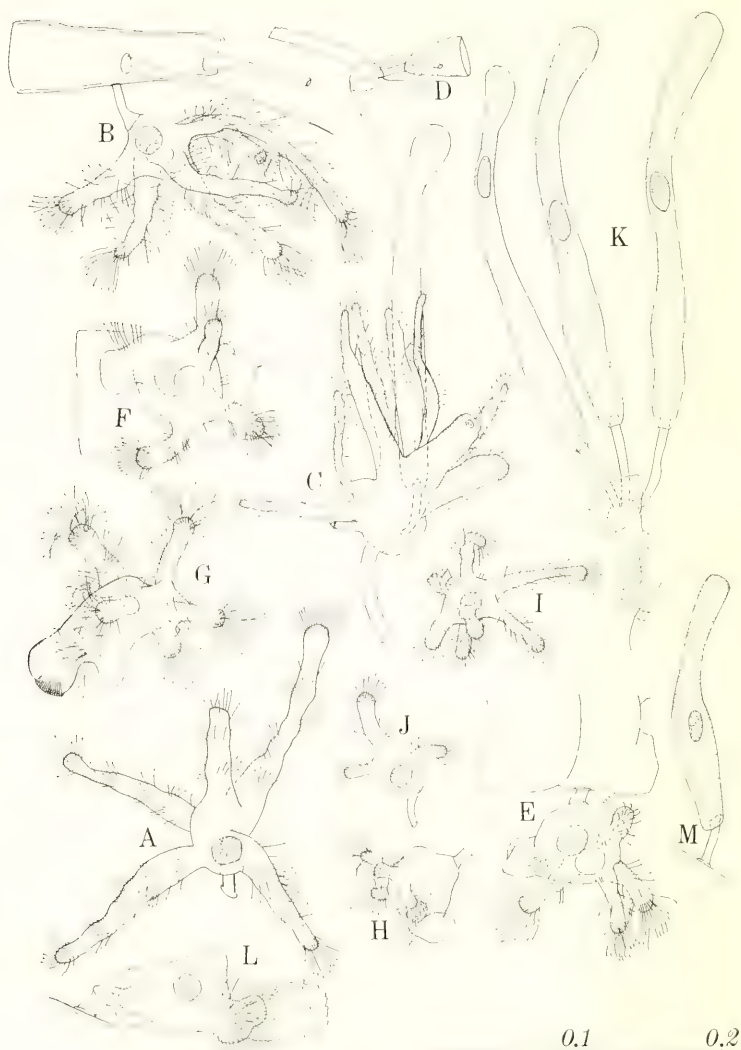


FIG. 2. *Dendrosomides lucicutiae*: A-J, from ♀ *Lucicutia gaussae*, T. N. GILL Cruise 4, sta. 51. A, Holotype, at base of caudal seta; B, On ventral surface of left caudal ramus; C, On right side of last pediger; D, Another view of same, showing stalk of vermiform attached to stalk of dendritic; E, On left side of anal segment; F, Same, from above arms; G, On ventral surface of urosomite 3 (nucleus omitted); H, On dorsal surface of anal segment (5th arm hidden by body, not shown);

more or less distinct nodes and a denser cluster of tentacles at distal end. Macronucleus spherical to elliptical, located at center of body slightly distal to attachment of stalk, not branching into arms. Contractile vacuole, when present, in body distal to macronucleus; diameter subequal to that of nucleus. Vermiform individuals much longer than dendritic specimens, up to nearly 300 μm , slightly inflated at apex; stalk usually longer; location of macronucleus variable, somewhat proximal or distal to midlength. Basal bodies randomly distributed in both dendritic and vermiform specimens.

Measurements: Dendritic individuals, stalk 10–70 μm ; width of body 50–60 μm ; length of tentacle 40–140 μm ; diameter of nucleus 16–21 μm . Vermiform individuals, stalk about 60 μm ; body length 260–280 μm .

Relationships: *D. lucicutiae* differs most significantly from other species of *Dendrosomides* by the form of the macronucleus. In other species of *Dendrosomides* the macronucleus is elongate and branches into the arms; in *D. lucicutiae* the spherical to elliptical macronucleus is confined to the body. Such a difference might seem to justify the erection of a separate genus for *D. lucicutiae*, but a number of ciliate genera (e.g., *Blepharisma*, *Stentor*) have quite different macronuclei in different species of the same genus.

D. lucicutiae most closely resembles *D. paguri* Collin, the type-species of the genus, but, in addition to the unbranched macronucleus, has 4–8 arms in contrast to the 3 in *D. paguri*. The constancy of the 3 arms in *D. paguri* is evident from Collin's (1912) statement that in examining 200–300 specimens, he found 3 arms in all but 1 specimen; the latter had 4 arms.

The vermiform stage of *D. paguri* has a nearly random distribution of basal bodies, but at both ends there is a slight tendency for them to form longitudinal rows (Guilcher, 1951). No such tendency was observed in silver impregnated specimens of *D. lucicutiae*.

LIFE CYCLE

The life cycle of *D. lucicutiae* appears to be similar to that of *D. paguri* as given by Collin (1912). In the dendritic form of *D. paguri* a bud grows out of the body just proximal to the level at which the 3 arms branch from the body. The bud elongates into a vermiform individual

←

I, On lateral surface of left caudal ramus, from above arms; J, Same from side (only 3 arms shown); K, From ♀ *L. gaussae*, GILL Cruise 2, sta. 75, 3 vermiforms with stalks attached to stalk of former dendritic; L, From ♀ *L. gaussae*, GILL Cruise 2, sta. 71, on ventral surface of anal segment; M, Vermiform from ♀ *L. flavicornis*, NE of Madeira Is., on caudal ramus. Scale in mm.

which separates from its dendritic parent, attaches to a new host by a basal sucker, and develops a stalk. The vermiform individual buds off 2 arms near its base and develops tentacles, thereby becoming a 3-armed dendritic individual. Budding of ciliated embryos is not known in *Dendrosomides*. It was reported to occur in the related genus *Ophryodendron* by Martin (1909), but Guilcher (1951) states that external budding of vermiforms is the only method of reproduction in both *Ophryodendron* and *Dendrosomides*.

Presumably *D. lucicutiae* has a similar life history, but living specimens were not available for study, and the preserved specimens did not reveal the complete life history. A stage not shown by any of my specimens is that of an unstalked vermiform being budded from the body of the dendritic, hence it is not known how the vermiform of *D. lucicutiae* acquires its macronucleus. In *D. paguri* a branch of the dendritic macronucleus grows into the bud of the vermiform, but in *D. lucicutiae* division of the macronucleus, with one of the daughter nuclei passing into the vermiform seems likely. All well developed vermiforms were nucleated and attached by a stalk to the copepod host (Fig. 2M) or to the stalk of a dendritic (Fig. 2C, D, K).

What I interpret to be formation of dendritics from vermiforms by budding of arms is shown in Figs. 2C, E, F, G, H, and L. In all these individuals a broad arm with few or no tentacles represents the untransformed remnant of the parent vermiform. Comparison with fully formed vermiforms (Fig. 2K, M) indicates that formation of arms is accompanied by shortening and thickening of the vermiform body.

DISTRIBUTION

Both *Lucicutia gaussae* and *L. flavicornis* are widely distributed and are essentially circumglobal in tropical, subtropical and temperate regions (for details see Vervoort (1965), where *L. gaussae* is listed as *L. ovalis* Wolfenden). Whether or not the distribution of *D. lucicutiae* is as extensive remains to be determined. Its occurrence on both hosts from NE of the Madeira Islands suggests that it is widespread at least in the Atlantic. Vidal (1971) found high incidences of suctorians on 3 species of *Lucicutia* in the Arctic Ocean, but gave no information on their morphology.

INCIDENCE OF INFESTATION

The incidence of infestation of *Lucicutia* with *Dendrosomides lucicutiae* is summarized below:

T.N. Gill Cruise No.	Total no. of stations	<i>L. gaussae</i>		<i>L. flavicornis</i>	
		Sta. where present	Sta. with <i>D. lucicutiae</i>	Sta. where present	Sta. with <i>D. lucicutiae</i>
2	85	12	4	38	1
3	75	13	5	26	2
4	72	15	2	29	0

The preference of *D. lucicutiae* for *L. gaussae*, much the rarer of the 2 host species, is clearly evident. Of 22 specimens of *L. gaussae* encountered during enumeration of the calanoids from the Gill Cruises 2, 3, and 4, 20 carried *D. lucicutiae*. In contrast, in the 3 samples where *D. lucicutiae* occurred on *L. flavicornis* it was present on 1 of 4, 1 of 12, and 1 of 32 hosts.

POSITION ON THE HOST

Dendrosomides lucicutiae was found most commonly on the urosomites, caudal rami, and caudal setae, but in a few instances was attached to the 5th leg or the posterior prosome segment (pediger 4 + 5) (Table 1). Because of the limited mobility of the vermiform, which lacks cilia, infestation of a new host probably occurs during host copulation, at which time the urosomes of the copulating pair are in contact (Gauld, 1957). Thus the position of *D. lucicutiae* on the host favors transference of the infestation to a new host.

ACKNOWLEDGMENTS

I am grateful to Dr. W. Duane Hope for a Feulgen stain of the holotype, and to Ms. Linda Cullen for assistance with a silver impregnation. Dr. John L. Mohr kindly reviewed the manuscript.

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PROCEEDINGS
OF THE
BIOLOGICAL SOCIETY OF WASHINGTON

NOMENCLATURAL AND TAXONOMIC NOTES
ON THE PTERIDOPHYTES OF
COSTA RICA, PANAMA, AND COLOMBIA, I.

BY DAVID B. LELLINGER

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The purpose of this paper and the one which will follow it is to publish lectotypes, new combinations, and new species of pteridophytes that will be included in my forthcoming "Ferns and Fern-allies of Costa Rica, Panama, and the Chocó."

Throughout this paper in the citation of type specimens, the word "photo" followed by a number refers to the numbered series of photographs taken by C. V. Morton and distributed from the U.S. National Museum. Photographs by others are identified by the name (and number, if any) of the person or institution who took them.

The papers also include some new combinations and new species necessary for the correct naming of specimens that de la Sota and I collected in Colombia outside the Chocó region, and which may be based on types collected in countries other than Colombia.

The principal entries are in alphabetical order for easy reference. In those cases where the principal entries are taxonomic or nomenclatural synonyms, the disposition of these names is given as I understand it at present.

Adiantum deflectens var. *tremulum* Hieron.
Bot. Jahrb. Engler 34:487. 1904.

Lectotype: To fix the application of this name, I choose from among the syntypes cited by Hieronymus: Near Colonia Tovar, Edo. Aragua, Venezuela, *Fendler 81* (US).

Discussion: This variety intergrades with var. *deflectens* Mart., and does not seem worthy of distinction. It is characterized by having lobed

pinnae with incisions between the sori and large, sterile teeth along the margins of the pinnae adjacent to the sori.

Adiantum glaucophyllum Hooker, Sp. Fil. 2:40. 1851.

Lectotype: To fix the application of this name, I choose: Boquete, Varaguas [now Peia, Chiriquí], Panama, Feb 1849, *Seemann* (K not seen Kew photo). This is the specimen that later was illustrated by Hooker (Icon. Plant. 10: t. 961. 1854), and so is the logical lectotype. *Adiantum glaucophyllum* is a synonym of *A. andicola* Liebm.

Adiantum lucidum var. *pinnatum* Fourn. Mex. Pl. 129. 1872.

Lectotype: To fix the application of this name I choose: Teapa, Edo. Tabasco, Mexico, *Linden* (P not seen photo 2605). The other syntypes are: Oaxaca, Mexico, *Galeotti* 6487 and 6492 (both P neither seen). *Adiantum lucidum* var. *pinnatum* is a synonym of *A. petiolatum* Desv.

Adiantum tetraphyllum Humb. & Bonpl. ex Willd.
Sp. Pl. ed. 4, 5:441. 1810.

Adiantum prionophyllum H.B.K. Nov. Gen. Sp. Pl. Prodr. 1:20 (fol. 16). 1815, nom. superfl. *Type*: A renaming of *A. tetraphyllum* Humb. & Bonpl. ex Willd., and so based on the lectotype of that name.

Lectotype: To fix the application of this name, I choose: Near Guanaguana and Caripe, Edo. Monagas, Venezuela, *Humboldt & Bonpland* (B-Hb. Willd. 20082-2 not seen Tryon photo). The other syntype is: West Indies, *Vahl* (B-Hb. Willd. 20082-1 not seen Tryon photo).

Adiantum tetraphyllum var. *majus* Fourn. Mex. Pl. 129. 1872.

Discussion: Because Fournier cites only Mexican specimens and a single valid species (*A. fruticosum* Kunze ex Spreng.) in synonymy, but gives no description, it is mandatory to base the variety on the cited synonym, the type of which is Cuba, *Poeppig* in 1822 (LZ destroyed; isotypes B not seen fragm US, L not seen photo 259). At least one of the cited specimens (*Galeotti* 6490) is *A. pulverulentum*, and several others are *A. tetraphyllum*. Possibly none of the cited specimens are *A. fruticosum*.

Adiantum trapeziforme L. Sp. Pl. 2:1097. 1753.

Lectotype: To fix the application of this name, I choose: Plate 59 of Sloane's "Voyage," which Linnaeus called "bona." Linnaeus' description "pinnis rhombeis" agrees better with this plate than it does with the specimen labelled "Adiantum 14 trapeziforme" in the hand of

Linnaeus (LINN 1252.13 not seen microfiche S.I. Library). This specimen, although it was in the Linnaean herbarium in 1753, represents the species long known as *A. tenerum* Swartz, and so is not a suitable lectotype.

Aspidium eurylobum Christ in Bomm. & Christ,
Bull. Soc. Bot. Belg. 35:206. 1896.

Lectotype: To fix the application of this name, I choose: Puerto Viejo, confluent with the Río Sarapiquí, Pcia. Heredia, Costa Rica, *Pittier* 6934 (BR not seen photo 19793; isoelectotypes CR, US). The other syntypes are: *Pittier* 7473 (BR not seen photo 19792; isosyntypes CR, US) from the same locality; and Tsáki, Talamanca, Pcia. Limón, Costa Rica, 200 m alt, *Pittier* 9445 (BR not seen photo 19797; isosyntype CR). The latter also is a syntype of *Aspidium myriosorum* Christ under the number 9995. *Aspidium eurylobum* is a synonym of *Tectaria nicotianifolia* (Baker) C. Chr.

Aspidium myriosorum Christ, Bull. Herb. Boiss. II, 5:256. 1905.

Lectotype: To fix the application of this name, I choose: Santa Clara, Las Delicias, Pcia. Limón, Costa Rica, 500 m alt, *Biolley* 10684 (US; isoelectotype P not seen). The other syntypes are: Río Hondo, Madre de Dios, Pcia. Limón, Costa Rica, 200 m alt, *Pittier* 10348 (P not seen; isosyntype US) and Tsáki, Talamanca, Pcia. Limón, Costa Rica, *Tonduz* 9995 (P not seen; isosyntype CR). The latter also is a syntype of *Aspidium eurylobum* Christ. *Aspidium myriosorum* is a synonym of *Tectaria draconoptera* (D. C. Eaton) Copel.

Discussion: The Colombian material of this species is a little more glossy than the Central American, but I can find no substantial character to separate the two.

Aspidium rivale Mett. ex Kuhn, Linnaea 36:120. 1869.

Lectotype: To fix the application of this name, I choose: Bay of Utria, Depto. Chocó, Colombia, *Seemann* (US; isoelectotype B not seen). The other syntype, Chagres, Canal Zone, Panama, *Fendler* 406 (B not seen Killip photo), is *Tectaria rheosora* (Baker) C. Chr. *Aspidium rivale* is a synonym of *Tectaria rivalis* (Mett. ex Kuhn) C. Chr.

Asplenium auritum f. *diversifolium* Rosenst.
Hedwigia 46:104. 1906.

Lectotype: To fix the application of this name, I choose: Lages, Est. Sta. Catarina, Brazil, *Spannagel* (Rosenst. Fil. Austrobras. Exs. 361) (S not seen; isoelectotypes L not seen photo 486, P not seen photo 4144). *Asplenium auritum* f. *diversifolium* clearly is a synonym of *A.*

cuspidatum var. *foeniculaceum* (H.B.K.) Morton & Lellinger, which is known from Costa Rica, Colombia to Bolivia, and southern Brazil.

Asplenium bradeorum Hieron. Hedwigia 60:217. 1918.

Lectotype: To fix the application of this name, I choose Tablazo, Pcia. S. José, Costa Rica, 1900 m alt, A. & A. C. Brade (*Rosenst. Fil. Costar. Exs. 11*) (B not seen; isotypes UC, fragm US). The other syntype, Mt. Tolima, Depto. Tolima, Colombia, *Lehmann* 2295 (B not seen), presumably is not *A. miradorensis*, which is a Central American species. *Asplenium bradeorum* is a synonym of *A. miradorensis* Liebm.

Asplenium conquisitum Underw. & Maxon ex Christ,
Bull. Herb. Boiss. II, 7:270. 1907.

Lectotype: To fix the application of this name, I choose: Mabess River, Jamaica, 3000 ft alt, *Maxon* 1558 (US), which is the sheet Maxon designated as holotype for the species which he and Underwood never published. Although both Maxon and Christ thought *A. conquisitum* was a distinct species, it has proved to be a synonym of *A. rutaceum* (Willd.) Mett.

Asplenium erectum var. *lagesianum* Rosenst. Hedwigia 46:98. 1906.

Lectotype: To fix the application of this name, I choose: Lages, Est. Sta. Catherina, Brazil, *Spannagel* 4 (*Rosenst. Fil. Austrobras. Exs. 390*) (US; isoelectotype S not seen). *Asplenium erectum* var. *lagesianum* is a synonym of *A. harpeodes* Kunze.

Asplenium harpeodes var. *incisum* Hieron.
Hedwigia 60:238. 1919.

Lectotype: To fix the application of this name, I choose: Unduavi, North Yungas, Depto. La Paz, Bolivia, 3200 m alt, *Buchtien* 101 (US; isoelectotypes B not seen, P not seen photo 4167). *Asplenium harpeodes* var. *incisum* is a synonym of *A. harpeodes* Kunze.

Asplenium induratum Christ,
Bull. Soc. Roy. Bot. Belg. 35: Mém. 201. 1896.

Diplazium induratum Diels, Nat. Pflanz. 1(4):226. 1899. *Type*: Based on *A. induratum* Christ, non Hooker, 1861, nom. illeg., and so based on the type of that name.

Lectotype: To fix the application of this name, I choose: Tsâki Cordillera de Talamanca, Pcia. Limón, Costa Rica, 200 m alt, *Tonduz* 9438 (US; isoelectotype BR not seen). The other two syntypes are from the same locality, *Tonduz* 9465 (BR not seen; isosyntype US) and

9466 (BR not seen; isosyntype US). *Asplenium induratum* is a synonym of *Diplazium lindbergii* (Mett.) Christ.

Asplenium lindbergii Mett. Ann. Sci. Nat., Paris V, 2:236. 1864.

Lectotype: To fix the application of this name, I choose: Caldes, Brazil, *Lindberg* 543 (B not seen), examined by D. E. Meyer (in litt. 28 June 1976). The other syntypes are from Colombia, Venezuela, and Mexico. *Asplenium lindbergii* is a synonym of *Diplazium lindbergii* (Mett.) Christ.

Discussion: The Andean material may represent a different species, *D. subnudum* (Karst.) Alston. Alston (J. Washington Acad. Sci. 48: 432. 1958) thought that "the Andean specimens are more deeply lobed than the typical . . . of Brazil." Such specimens in the U.S. National Herbarium seem to me to have wider and more persistent indusia, thus confirming Alston's opinion.

Asplenium radicans var. *uniseriale* (Raddi)

Lellinger, comb. nov.

Asplenium uniseriale Raddi, Opusc. Sci. Bologna 3:291. 1819. *Type*: Brazil, *Raddi* (FI not seen).

Discussion: This variety intergrades a little with var. *partitum* (Klotzsch) Hieron. and, apparently, with var. *tripinnatum* Mett.

Asplenium sodiroi Christ in Pitt.

Prim. Fl. Costar. 3(1):26. 1901.

Asplenium ebeneum sensu Sodiro, Anal. Univ. Quito 8(58):271 (repr. 146). 1893.

Lectotype: To fix the application of this name, I choose: Andes of Quito, Pcia. Pichincha, Ecuador, *Sodiro* (P-Hb. Christ not seen photo 4250). The other syntype cited by Christ is: Santa Rosa du Copey, Pcia. S. José, Costa Rica, *Tonduz* 12333 (CR or P not seen fragm US), and is *A. sessilifolium* Desv. *Asplenium sodiroi* may be a valid species, or it may prove to be a form or variety of *A. sessilifolium*.

Asplenium trianae Mett. Ann. Sci. Nat. Paris V, 2:233. 1864.

Lectotype: To fix the application of this name, I choose: Prov. de Barbacoas, via de Túquerres, Depto. Nariño, Colombia, 900 m alt, *Triana* in 1853 (BM not seen photo 7049; isoelectotype B? not seen). The other syntype is: Ingara, Depto. Chocó, Colombia, *Triana* 157 (B? not seen; isosyntype P not seen photo 4129). *Asplenium trianae* is a synonym of *Diplazium trianae* (Mett.) C. Chr.

Athyrium palmense (Christ) Lellinger, comb. nov.

Cystopteris fragilis var. *palmensis* Christ, Bull. Herb. Boiss. II, 7:264. 1907. Type: La Palma, Pcia. S. José, Costa Rica, 1500 m alt, Wercklé 17054 (P).

Discussion: This species resembles *A. skinneri* (Baker) Moore, especially in pinnule architecture, but differs in the usually alternate pinnae and subflexuous rachises and in the 2-3-pinnate-pinnatifid, not pinnate-pinnatifid or 2-pinnate frond division. The subflexuous rachises are more evident in the specimens from El Salvador and Mexico than they are in most of the specimens from Costa Rica.

Athyrium reductum Christ, Bull. Herb. Boiss. II, 4:966. 1904.

Lectotype: To fix the application of this name, I choose: Alajuelita, Pcia. S. José, Costa Rica, Alfaro 16472 (US; islectotypes GH, P not seen). The other syntype is: Ecuador, Sodiro (PP not seen), which presumably is a specimen of *A. dombeyi* Desv., a species that resembles *A. reductum*. Christ also cited the holotype of *A. ordinatum* Christ, Wercklé 60 (P not seen photo 4041, US); this is an obvious error. The holotype bears only the name "*Athyrium ordinatum* Chr." because it is the holotype of that species, which appears on the page following the description of *A. reductum*. The two species differ primarily in the substantial character of size, and clearly are taxonomic synonyms. I cannot find any work which synonymizes either of these species under the other one. I adopt *A. ordinatum* because it is more clearly typified, and so make *Athyrium reductum* a synonym of *A. ordinatum*.

Campyloneurum falcoideum (Kuhn ex Hieron.)

M. Meyer ex Lellinger, comb. nov.

Polypodium falcoideum Kuhn ex Hieron. Bot. Jahrb. Engler 34:533. 1904. Syntypes: Río Sucio, Costa Rica, 800 m alt, Lehmann 1741 (B not seen; isosyntype US); and Near Desengaño, Pcia. Heredia?, Costa Rica, Wendland 876 (B not seen).

Discussion: Myriam Meyer is the author of an unpublished Ph.D. dissertation from Southern Illinois University, Carbondale, in 1964. Her conclusion that this species, which had been put in *Polypodium* sect. *Goniophlebium*, belongs in *Campyloneurum* is correct.

Campyloneurum multipunctatum (Christ) Lellinger, comb. nov.

Polypodium phyllitidis f. *multipunctatum* Christ, Bull. Herb. Boiss. II, 5:7. 1905. Type: Costa Rica, Wercklé 174 (P not seen).

Polypodium phyllitidis var. *elongatum* Hieron. Bot. Jahrb. Engler 34: 534. 1904, as "*elongata*." Syntypes: Río Paez, Depto. Tolima, Colombia, 800-1300 m alt, Lehmann 5721 (B not seen; isosyntype US);

and Cerro Yanghuan near Pindilic, Cordillera Oriental de Cuenca, Pcia. Azuay, Ecuador, 2500–2800 m alt, *Lehmann* 7679 (B not seen; isosynotype US).

Discussion: This species is very distinct from typical *C. phyllitidis* (L.) Presl. by its narrow, linear, dark green, extremely dull fronds.

Campyloneurum occultum (Christ) M. Meyer
ex Lellinger, comb. nov.

Polypodium occultum Christ, Bull. Herb. Boiss. II, 5:7. 1905. *Type:* Río de Las Vueltas, Tucurrique, Pcia. Cartago, Costa Rica, 364 m alt, *Tonduz* 12756 (P? not seen). *Tonduz* 12752 (US) is also this species from the same locality, and may actually be the type number if the published number is in error.

Ctenitis equestris var. *mutica* (Christ) Lellinger, comb. nov.

Aspidium effusum var. *muticum* Christ in Pitt. Prim. Fl. Costar. 3(1): 32. 1901. *Type:* Headwaters of the Río Bkís, Diquís basin, Pcia. Puntarenas, Costa Rica, 1500 m alt, *Pittier* 10597 (BR not seen; isotype US).

Dryopteris equestris var. *heterolepis* C. Chr. K. Danske Vidensk. Selsk. Skr. VIII, 6:56. 1920. *Type:* Vicinity of Boquete, Pcia. Chiriquí, Panama, *Maxon* 4951 (US; isotype C not seen).

Ctenitis hirsuto-setosa (Hieron.) Lellinger, comb. nov.

Dryopteris hirsuto-setosa Hieron. Hedwigia 46:343, t. 6, f. 16. 1907. *Type:* Above Allpayacu between Baños and Jivaria de Pintuc, Pcia. Tungurahua?, Ecuador, *Stuebel* 903 (B not seen).

Discussion: This species is a member of sect. *Subincisae*.

Ctenitis lunensis (Christ) Lellinger, comb. nov.

Aspidium lunense Christ, Bull. Herb. Boiss. II, 6:55. 1906. *Syntypes:* Pont du Río Navarro, Pcia. Cartago, Costa Rica, *Wercklé* (P not seen); and Luna, quebrada orientale, Pcia. S. José?, Costa Rica, *Wercklé* (P not seen; presumable isosynotype US).

Discussion: This species is closely related to *C. pansamalensis* (C. Chr.) Ching, and has exactly the same broad, flaccid scales on the axes, but has fewer, shorter, laxer hairs on the lamina undersurface, axes, and veins.

Ctenitis palmensis (Rosenst.) Lellinger, comb. nov.

Dryopteris subincisa var. *palmensis* Rosenst. Repert. Sp. Nov. Fedde 22:11. 1925. *Syntypes:* La Palma, Pcia. Heredia, Costa Rica, 1400 m

alt, A. & A. C. Brade 215a (S not seen), 1450 m alt, 17 Mar 1910
A. & A. C. Brade (S not seen).

Discussion: This species is unusual in sect. *Hirtae* in having broad, lanceate scales on the axes, rather than the hairlike ones that are typical of the section.

Ctenitis subdryopteris (Christ) Lellinger, comb. nov.

Phegopteris subdryopteris Christ in Pitt. Prim. Fl. Costar. 3(1):36.
1901. *Type:* Edge of the Río Pedregoso, Copey, Pcia. S. José, Costa Rica, 1800 m alt, *Tonduz* 11852 (BR not seen; isotype US).

Ctenitis submarginalis f. *caripensis* (Willd.)

Lellinger, comb. nov.

Polypodium caripense Humb. & Bonpl. ex Willd. Sp. Pl. ed. 4, 5:202.
1810. *Type:* Near Caripe, Edo. Monagas, Venezuela, *Humboldt* 428 (B-Hb. Willd. 19700-1 and 2 not seen Tryon photos).

Discussion: This name applies to material from Florida, Hispaniola, and Mexico through Venezuela, Colombia, and Ecuador. Other forms and varieties of the species exist in the Andes, Brazil, and southern South America, according to Christensen (K. Danske Vidensk. Selsk. Skr. VIII, 10:95-98. 1913).

Danaea humilis Moore, Ind. Fil. 286. 1861.

Lectotype: To fix the application of this name, I choose: Tarapoto, Depto. S. Martín, Peru, *Spruce* 4769 (K not seen; isotype L not seen photo 841), which has a terminal pinna, and thus is the only syntype that agrees with the original description. The other syntypes are: Cabo Corrientes, Depto. Chocó, Colombia, *Seemann* 996 (K? not seen); and "Panama" [probably Depto. Chocó, Colombia], *Fendler* 389 (K? not seen). Both are odd-pinnate, proliferous or potentially so, and clearly are specimens of *D. wendlandii* Reichenb.

Dicranoglossum panamense (C. Chr.) Lellinger, comb. nov.

Eschatogramme panamensis C. Chr. Dansk Bot. Ark. 6(3):37. 1929.
Type: Around the Agua Clara Reservoir near Gatun, Canal Zone, Panama, *Maxon* 4642 (US).

Diplazium crenulatum Liebmann,

K. Vidensk. Selsk. Skr. V, 1:254 (repr. 102). 1849.

Lectotype: To fix the application of this name, I choose: Between Colipa and Misantla, Edo. Veracruz, Mexico, *Liebmann* (US; isolectotype C not seen photo 5609). The other syntypes are: Barranca de Jovo, Edo. Veracruz, Mexico, *Liebmann* (C not seen photo 5607); and Hacienda de Mirador, Edo. Veracruz, Mexico, *Liebmann* (C not seen

photo 5608). *Diplazium crenulatum* is a synonym of *D. striatum* (L.) Presl.

Diplazium grandifolium var. *submarginatum* Rosenst.

Repert Sp. Nov. Fedde 22:9. 1925.

Lectotype: To fix the application of this name, I choose: Llanuras de S. Carlos, Pcia. Alajuela, Costa Rica, 200 m alt, A. & A. C. Brade 453 (S not seen photo 6280; isoelectotype NY). The other syntype is from the same locality, A. & A. C. Brade 381a (S not seen). *Diplazium grandifolium* var. *submarginatum* is a synonym of *D. seemannii* Moore.

Diplazium ingens Christ, Bull. Herb. Boiss. II, 4:970. 1904.

Lectotype: To fix the application of this name, I choose: Tsâki, Talamanca, Pcia. Limón, Costa Rica, 200 m alt, *Tonduz* 9443 (US; isoelectotype P not seen). The other syntypes are: Jiménez, Pcia. Limón, Costa Rica, 200 m, *Alfaro* 16506 (P not seen; isosyntype US); Costa Rica, *Wercklé* 239 (P not seen); and Zent, Pcia. Limón, Costa Rica, 31 m alt, *Tonduz* 14566 (P not seen photo 4047).

Discussion: This collection is also the type of *Asplenium radicans* var. *costaricense* Christ (Bull. Soc. Roy. Bot. Belg. 35: Mém. 202. 1896).

Diplazium obscurum Christ, Bull. Herb. Boiss. II, 7:269. 1907.

Lectotype: To fix the application of this name, I choose: Tablazo, Pcia. S. José, Costa Rica, 1900 m alt, *Biolley* 60 (US; isotype P not seen). The other syntypes are: Navarro, Pcia. Cartago, Costa Rica, *Wercklé* in 1905 (P not seen); and S. Lorenzo de Dota, Pcia. S. José, Costa Rica, *Pittier* 2239 (P not seen; isosyntype US).

Diplazium pactile Lellinger, sp. nov.

Figure 1

Planta terrestris. Rhizoma erectum ca. 2 cm diam. squamatum; paleis lineari-lanceolatis usque ad 7 mm longis 1 mm latis bicoloribus, parte centrali brunneolis fibrosis, marginibus castaneis rigidis dentatis dentibus bifidis. Stipites ca. 80 cm longi 8–10 mm lati cinnamomei carnosii profunde sulcati omnino sparse squamati; paleis eis rhizomatis similibus praediti. Rhachides cinnamomeae vel stramineae non profunde sulcatae non alatae sparse squamatae et dense pilosulae; pilis brunneis contortis catenatis usque ad 0.5 mm longis. Laminae 60–75(90?) cm longae 30–45 cm latae papyraceae lineari-lanceolatae pinnatae vel pinnato-pinnatifidae basin versus, ad basin obtusae, ad apicem acutae vel acuminatae infra pinnatifidae, supra lobatae; pinnis basalibus sessilibus vel petiolulatis (usque ad 4 mm) oppositis vel suboppositis usque ad 25 cm longis 6–8 cm latis; pinnis superioribus sessilibus vel adnatis, 4–6 paribus sub-

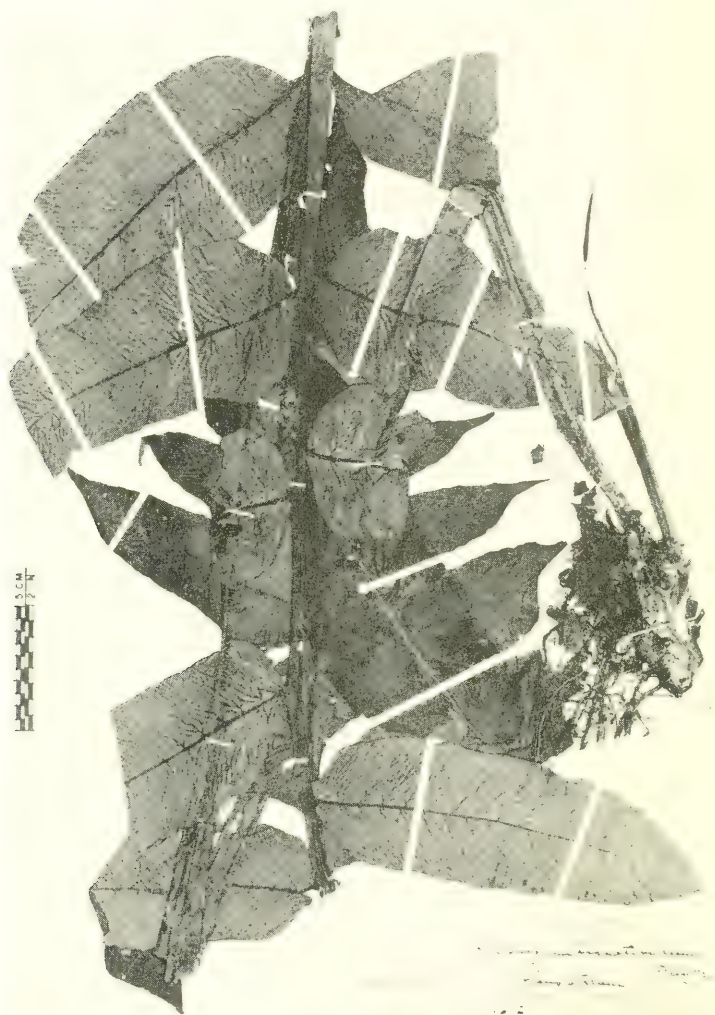


FIG. 1. Holotype of *Diplazium pactile* Lellinger, *Holdridge 1602* (US).

oppositis vel alternis 15–22 cm longis 4.5–6.5 cm latis; apice 20–30 cm longis 20–25 cm latis, lobis connatis et adnatis, infimis acutis, supernis rotundatis, areolis demissis secus rhachim praeditis; pinnis linearibus vel lanceolatis aequilateralibus integris irregulariter crenatis vel pinnatifidis ($1/3$ ad costam), costis usque ad 2 mm diam. infra cinnamomeis, paleis

et pilis eis rhachidis praeditis, supra stramineis glabris leviter sulcatis, in pinnis pinnatifidis costulis rectis, usque ad 25 paribus suboppositis vel alternis, venulis 1-furcatis anastomosantibus in 1 vel 2 seriebus, in pinnis integris costulis basin versus rectis, marginem versus subdichotomis 3-4-furcatis anastomosantibus in 3-5 seriebus; paginis supra glabris, venulis prominulis; paginis infra sparse pilosulis, pilis eis rachidis praeditis, venulis prominulis. Sori lineares. Indusia continua ca. 0.2 mm lata membranacea integra demum erosa.

Type: Vicinity of Santo Domingo de los Colorados, Pcia. Pichincha, Ecuador, 500 m alt, *Holdridge 1692* (US).

Paratypes: Near the Finca Sepacuite, Depto. Alta Verapaz, Guatemala, *Cook & Griggs 54* (US); Tsáki, Talamanca, Pcia. Limón, Costa Rica, ca. 200 m alt, *Tonduz 9446* (US); Vicinity of Guápiles, Pcia. Limón, Costa Rica, 300-500 m alt, *Standley 37237* (US).

Discussion: This species of subg. *Anisogonium* resembles *D. wallisii* Baker in texture, division, and venation. It is a little like *D. pinnatifidum* Kunze, but that species is smaller, more glabrous, and much more coriaceous.

Diplazium sanctae-rosae Christ, Bull. Herb. Boiss. II, 7:268. 1907.

Lectotype: To fix the application of this name, I choose: Sta. Rosa de Copey, Pcia. San José, Costa Rica, 1800 m alt, *Tonduz 12187* (US; isolectotype P not seen). The other syntype is: Costa Rica, *Wercklé 83* (P not seen).

Diplazium subsilvaticum Christ in Pitt.

Prim. Fl. Costar. 3(1):28. 1901.

Lectotype: To fix the application of this name, I choose: Cañas Gordas, Pcia. Puntarenas, Costa Rica, 1100 m alt, *Pittier 10982* (US; isolectotype P not seen). The other syntype is: Achiote, Volcán Poás, Pcia. Alajuela, Costa Rica, 2200 m, *Tonduz 10728* (P not seen).

Diplazium tomentellum (Rosenst.) Lellinger, comb. nov.

Diplazium hians var. *tomentellum* Rosenst. Repert. Sp. Nov. Fedde 22:9. 1925. *Type:* Tablazo, Pcia. S. José, Costa Rica, 1900 m alt, A. & A. C. Brade 803 (S not seen fragm US).

Gleichenia brevipubis Christ, Bull. Herb. Boiss. II, 6:280. 1906.

Lectotype: To fix the application of this name, I choose: Valley of the Rio Navarro, Pcia. Cartago, Costa Rica, 1400 m alt, *Wercklé* in 1905 (P not seen photo 4478; isolectotype US). The other syntype is: Meseta Central de S. José, Pcia. S. José, Costa Rica, 2000 m alt, *Alfaro 16871* (P not seen photo 4479). The lectotype is a better developed and more typical specimen.

Gleichenia maritima Hieron. Bot. Jahrb. Engler 34:562. 1905.

Lectotype: To fix the application of this name, I choose: Near Buenaventura, Depto. El Valle, Colombia, *Lehmann* 4432 (B not seen photo 10337; isotype US). The other syntype is: Above Cordova on the Río Dagua, Depto. El Valle, Colombia, *Lehmann* 742 (B not seen photo 10338).

Gleichenia pectinata var. *sublinearis* Christ,
Bull. Herb. Boiss. II, 6:282. 1906.

Lectotype: To fix the application of this name, I choose: Navarro, Pcia. Cartago, Costa Rica, 3500 ft alt, *J. D. Smith* 4994 (US; isolectotype P not seen). The other syntypes are: Navarro, Pcia. Cartago, Costa Rica, *Wercklé* (P not seen); Helechales du General, vallée du Diquís, Pcia. Puntarenas, Costa Rica, 700 m alt, *Pittier* 12063 [not 1263] (P not seen; isosyntype US); Boruca, Pcia. Puntarenas, Costa Rica, *Pittier* 4437 (P not seen; isosyntype US); and Santiago, Costa Rica, 900 m alt, *Wercklé* 16912 (P not seen). *Gleichenia pectinata* var. *sublinearis* is a synonym of *Dicranopteris pectinata* (Willd.) Underw.

Grammitis dolorensis (Hieron.) Lellinger, comb. nov.

Polypodium dolorense Hieron. Bot. Jahrb. Engler 34:512. 1904. *Type*: Santa Rosa, Depto. Antioquia, Colombia, 1700–2200 m alt, *Lehmann* 7380 (B? not seen; isotype US).

Discussion: This species is like *G. chrysleri* (Copel.) Proctor, but has many stiff setae on the laminae beneath.

Grammitis epiphytica (Copel.) Lellinger, comb. nov.

Ctenopteris epiphytica Copel. Phillip. J. Sci. 84:436. 1956. *Type*: La Trojita, Río Calima, Depto. Valle, Colombia, 5–50 m alt, *Cuatrecasas* 16723 (US).

Discussion: This species, which is closely related to *G. isidrensis* (Copel.) Seymour, is known only from the type.

Grammitis hombersleyi (Maxon) Lellinger, comb. nov.

Polypodium hombersleyi Maxon, Amer. Fern J. 20:1. 1930. *Type*: Gully at mile 10.25 of the Blanchisseuse Road, Trinidad, epiphytic in moss at 2200 ft, *Hombersley* 331 (US).

Discussion: This species is distinctive in its diminutive size, crenate margins, and few, pale, short trichomes on the stipe and rachis.

Grammitis limula (Christ) Lellinger, comb. nov.

Polypodium limulum Christ, Bull. Soc. Bot. Genève II, 1:218. 1909.

Lectotype: To fix the application of this name, I choose: La Palma,

Pcia. Heredia, Costa Rica, 1459 m alt, *Tonduz* 12595 (US; isolectotype P not seen). The other syntypes are: La Palma, Pcia. San José, Costa Rica, *Pittier* 708, *Brade* 79, and *Wercklé* in 1903 (all P none seen).

Grammitis nigrolimbata (Jenm.) Lellinger, comb. nov.

Polypodium nigrolimbatum Jenm. Bull. Dept. Agr. Jamaica 4:69. 1897.

Type: Near Tarapoto, Depto. S. Martín, Peru, *Spruce* 4643 (K not seen); see Hooker (Sp. Fil. 4:164. 1864).

Grammitis pearcei (Bak. in Hook. & Bak.) Lellinger, comb. nov.

Polypodium pearcei Bak. in Hook. & Bak. Syn. Fil. 508. 1874. *Type:* Quichara, Peru or Bolivia?, 6000–7000 ft alt, *Pearce* (K not seen).

Discussion: Copeland (Phillip. J. Sci. 84:467. 1956) included this as a synonym of the Brazilian species *Grammitis albidula* (Baker) Morton (as *Ctenopteris*), but the holotype, *Glaziou* 3579 (BR not seen photo 4971) shows that *G. albidula* has long stipes. *Grammitis pearcei* is slightly farinose beneath and has superficial sori. It is related to *G. curvata* (Swartz) Ching, which is not farinose and has slightly sunken sori.

Grammitis rosulata (Christ) Lellinger, comb. nov.

Polypodium rosulatum Christ, Bull. Herb. Boiss. 4:662. 1896. *Type:* Río Naranjo, Costa Rica, *Pittier* 7953 (BR not seen photo 5027).

Grammitis semihirsuta var. *fuscasetosa* (Hieron.)
Lellinger, comb. nov.

Polypodium semihirsutum var. *fuscetosum* Hieron. Bot. Jahrb. Engler 34:515. 1904, as "*fuscetososa*." *Syntypes:* Río Dagua, Depto. Cauca, Colombia, 1500 m alt, *Lehmann* 2982 p. p. (B not seen); Mt. Tolima, Depto. Tolima, Colombia, Mar 1882, *Schmidtchen* (B not seen); Near Tatanera, Depto. Puno, Peru, *Lechler* 2551 (B not seen), 2570 (B not seen); and Near S. Miguel Uspantan, Depto. Quiché, Guatemala, 2100–2200 m alt, *Heyde & Lux* (J. D. Smith 3256) (B not seen; isosyntype US).

Discussion: This variety has reddish brown to pale setae ca. 1 mm long scattered between the veins beneath, in contrast to var. *semihirsuta*, which is glabrous between the veins beneath, and to *G. al-sopteris* Morton, which has dark setae mostly ca. 0.25 mm long abundant between the veins beneath. The Guatemalan syntype seems to be var. *semihirsuta*, and since I have seen none of the other syntypes, I do not wish to choose a lectotype.

Grammitis staheliana (Posth.) Lellinger, comb. nov.

Polypodium stahelianum Posth. Rec. Trav. Bot. Neerl., Leiden 23:401. 1927. *Type*: Emmaketen, Suriname, 700 m alt, *Gonggrijp & Stahel* 5765 (U not seen photo 23).

Discussion: This rarely collected species, thought by Kramer (Amer. Fern J. 64:114. 1974) to be endemic to Suriname, is now known also from Nicaragua, Venezuela, and Colombia.

Hymenophyllum ceratophylloides Christ,
Bull. Herb. Boiss. II, 4:942. 1904.

Lectotype: To fix the application of this name, I choose: Costa Rica, *Wercklé* 280 (P not seen). Morton has written on a description of this species (US), "The CR type in P is a *Sphaerocionium* . . . the Ecuador is *Euhymenophyllum*." The other syntype is: Quito, Pcia. Pichincha, Ecuador, *Sodiño* (P not seen). In all probability, *H. ceratophylloides* is a synonym of *H. lineare* (Swartz) Swartz.

Hymenophyllum siliquosum Christ,
Bull. Herb. Boiss. II, 4:938. 1904.

Lectotype: To fix the application of this name, I choose: Costa Rica, *Wercklé* 289 (P not seen). The other syntype, Costa Rica, *Wercklé* 307 (P not seen; isotype CR), is *H. (Sphaerocionium) lineare* (Swartz) Swartz. *Hymenophyllum siliquosum* is a member of subg. *Mecodium*.

Hypolepis pulcherrima Underw. & Maxon,
Proc. Biol. Soc. Washington 43:84. 1930.

Hypolepis purdicana sensu Jenm. Bull. Bot. Dept. Jamaica 36:10. 1892, non *H. purdieana* Hooker, 1852.

Lectotype: In publishing their name, Underwood and Maxon considered Jenman's name to be a validly published later homonym, rather than a sensu name. But this is not the case, and since sensu names are not validly published and have no types, a lectotype must be chosen from among the specimens cited by Underwood and Lloyd, whose name must be considered a new species with a description provided by Jenman. I choose: Blue Mountain Peak, Jamaica, *Maxon* 9912 (US).

Lastreopsis chontalensis (Fourn.) Lellinger, comb. nov.

Aspidium chontalense Fourn. Bull. Soc. Bot. France 19:254. 1872.

Type: Chontales, Depto. Chontales, Nicaragua, 600 m alt, *Lévy* 516 (P not seen photo 4657; isotype fragm US).

Nephrodium guatemalense Bak. in Hook. & Bak. Syn. Fil., ed. 2. 498. 1874.

Lectotype: Choctum, Guatemala, *Salvin & Godman* (K not seen), chosen by Christensen (K. Danske Vidensk. Selsk. Skr. VIII, 6:96. 1920).

Discussion: This species differs from *L. exculta* (Mett.) Tindale in its narrower laminae and more closely set median pinnae.

Lycopodium attenuatum Spring, Monogr. Lyc. 2:8. 1850.

Lectotype: To fix the application of this name, I choose: Mt. Pichincha, Pcia. Pichincha, Ecuador, 11500 ft alt, *Hartweg 1470* (US; isolectotype LG? not seen). The other syntype is: Andes of Quito, Pcia. Pichincha, Ecuador, 11000–11500 ft alt, *Jameson* (K not seen).

Lycopodium pensum Lellinger & Mickel, sp. nov.

Figure 2

Planta terrestris. Rhizoma ignotum. Caulis primarius erectus teres 1 m longus usque ad 4(6?) mm latus ad basin sparse hirsutus foliaceus; foliis adpressis distantibus sublanceolatis late affixis ad basin acuminatis vel subaristatis ad apicem 6–8 mm longis 1 mm latis irregulariter et breviter ciliatis, ciliis unicellularibus rigidis. Caules secundarii horizontales suboppositi vel fere verticillati usque ad 30 cm longi 2 mm lati hirsuti foliacei; foliis adpressis similibus illis caulis primarii 5–7 mm longis 0.8–1 mm latis subimbricatis. Caules tertiarii alterni 1–3.5(6.5) cm distantes cernui hirsuti 3–5-plo dichotomi usque ad 15 cm longi; ramulis ca. 1.5 mm diam. hirsutis foliaceis, foliis subadpressis similibus illis caulibus secundariis 3–4 mm longis 0.4–0.75 mm latis imbricatis. Strobili sessiles usque ad 18 mm longi 5 mm lati. Sporophylla late lanceolata usque ad 3 mm longa 1 mm lata patentia, marginibus ciliatis albidis; sporangiis subsphaericis ca. 0.8 mm in diam.

Type: 6 mi. from S. Rafael de Heredia on slopes of Volcán Barba [Cerro Chompipe]; swampy cloud forest at the end of the road, Pcia. Heredia, Costa Rica, *McAlpin 216* (DUKE; fragm GH).

Paratypes: Atlantic slope of Volcán Barba, Pcia. Heredia, Costa Rica, ca. 2000 m alt 14 Aug. 1964, *R. E. Woodruff* (FLAS, US); 12.3 mi. below Villa Mills on Interamerican Highway, Pcia. S. José, Costa Rica, *McAlpin 2377* (US).

Discussion: This species is a member of the *L. cernuum* group and is related to *L. trianae* Hieron. in having hirsute stems and ciliate leaves. Among the *L. cernuum* group, it is more treelike in its habit than most, and can be distinguished by its long, drooping tertiary branches.

Lycopodium pflanzii (Nessel) Lellinger, comb. nov.

Urostachys pflanzii Nessel, Repert. Sp. Nov. Fedde 36:181, t. 171.

1934. *Syntypes*: Near Corocoro, Depto. La Paz, Bolivia, *Pflanz* in 1920 (Hb. Nessel not seen; isotype fragm US); and San Benito,

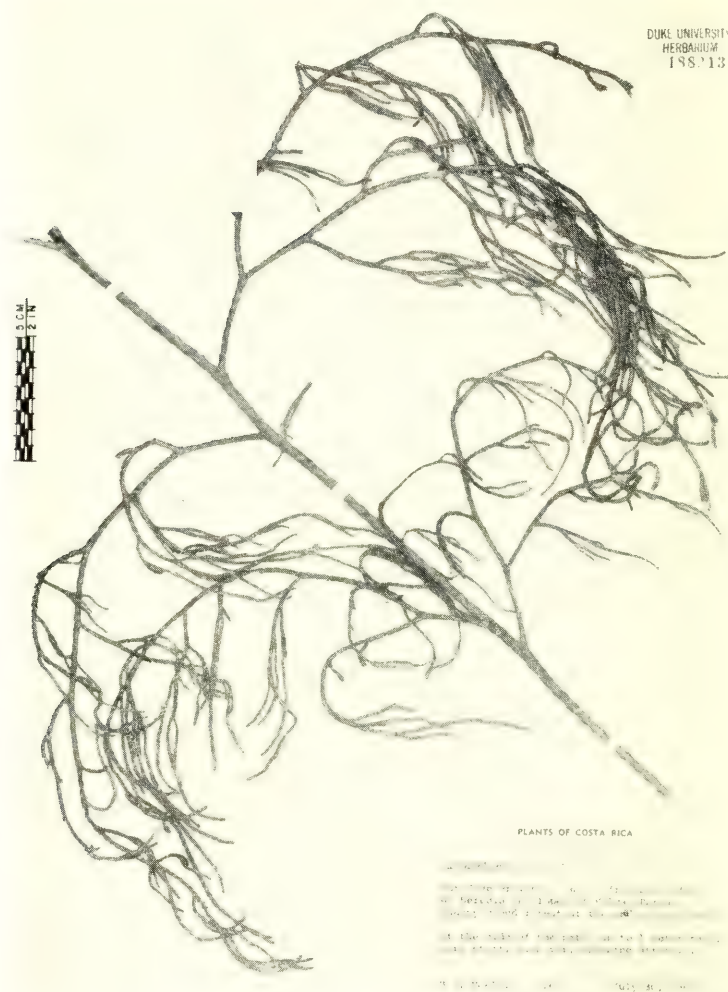


FIG. 2. Holotype of *Lycopodium pensum* Lellinger & Mickel, *McAlpin 216* (DUKE).

Sacaba, Depto. Cochabamba, Bolivia, 3000–4000 m alt, 14 Nov 1921, *Steinbach* (B not seen).

Discussion: This species is a member of the *L. saururus* group and is notable for its broad, widely flaring leaves with distinct keel and

wide band of specialized marginal cells. It is known from one locality, Cerro de la Muerte, in Costa Rica (*Tryon & Tryon 7055*, GH).

Lycopodium trianae Hieron. Bot. Jahrb. Engler 34:574. 1905.

Lectotype: To fix the application of this name, I choose: Acostadero [Arrostradero, t. Hieron.], Depto. Chocó, Colombia, 2500 m alt, *Triana 234* (US; isoelectotype B not seen). The other syntype is: Near Buenaventura, Depto. Valle, Colombia, *Lehmann 8910* (B not seen; isosyntype US).

Lycopodium verticillatum var. *parvifolium*
(Wercklé ex Nessel) Lellinger, comb. nov.

Urostachys verticillatus var. *parvifolius* Wercklé ex Nessel, Rev. Sudamer. Bot. 6:163, f. 43. 1940. *Type*: Volcán Barba, Pcia. Heredia, Costa Rica, 2100 m alt, A. & A. C. *Brade 283* (HB not seen).

Discussion: This variety is slightly distinct from typical material from Réunion in its shorter, more spreading sterile leaves.

Oleandra zapatana Lellinger, sp. nov.
Figure 3

Planta epiphytica. Rhizoma scandens 2–3.5 mm diam. squamatum ramosum; ramis sub angulo 90° abeuntibus et inter se 1–4 cm distantibus; paleis lineari-lanceolatis peltatis 4–7 mm longis 0.5–0.8 mm latis concoloribus (puncto insertionis excepto) pallide brunneis sublaxis, marginibus sparse ciliolatis, apice subcontortis. Phyllopodia 1–2 cm longa ca. 1 mm lata castanea vel brunnea nitida. Stipites sicut costae sulcati, subtus brunnei, supra obscure castanei. Stipites (2.5)5–7 cm longi (0.75)1–1.5 mm diam. nitidi glabri vel sparse pilosi; pilis 0.25–0.5 mm longis laxis subglandulosi. Costae pilosae; pilis 0.5–2 mm longis laxi. Laminae membranaceae lineari-lanceolatae, ad basin acutae, ad apicem abrupte acuto- vel acuminato-caudatae, 18–28 cm longae 4–7 cm latae simplices; marginibus integris glabris vel sparse pilosulis prope costam; venis 9–15 per cm simplicibus vel 1-furcatis. Sori indusiati plusminusve mediales pauci sparsi; indusiis circularibus ca. 0.8 mm diam. debilibus pilosis.

Type: Trail along ridge from the confluence of the forks of the Río Mutatá above the Río Dos Bocas to the top of Alto del Buey, Depto. Chocó, Colombia, ca. 1450–1750 m alt, *Lellinger & de la Sota 300* (US; isotypes COL, LP).

Paratype: Hillside above the Río Mutatá ca. 3 km above its junction with the Río El Valle near the base of Alto del Buey, Depto. Chocó, Colombia, ca. 850 m alt, *Lellinger & de la Sota 195* (US; isoparatype LP).



FIG. 3. Holotype of *Oleandra zapatana* Lellinger, Lellinger & de la Sota 300 (US).

Discussion: This species is most closely related to *O. nodosa* (Willd.) Presl [syn. *O. articulata* (Swartz) Presl], from which it differs in its rather densely pilose stipe apex and midrib. The lamina surface near the midrib is also often short-pilose.

Phegopteris refulgens Mett. in Tr. & Planch.

Ann. Sci. Nat. Paris V, 2:240. 1864.

Lectotype: To fix the application of this name, I choose: Mouth of the Río Nercua, Depto. Chocó, Colombia, *Schott* 7 (US; presumable isoelectotype B not seen). The other syntypes are: Mt. Tolima, Depto. Tolima, Colombia, *Linden* 1011 (B not seen); Magdalena, Colombia, 100 m alt, *Lindig* 382 (B not seen); and Guyana, *Schomburgk* 1183 (B not seen).

Pityrogramma dukei Lellinger, sp. nov.

Figure 4

Planta terrestris. Rhizoma erectum vel ascendens 2–3 mm diam. squamatum; paleis lanceatis usque ad 1 mm longis 0.33 mm latis concoloribus rufobrunneis nitidis rigidis, cellulis tumidis, marginibus carinatis. Stipites 14–31 (34) cm longi 1–1.5 mm lati atropurpurei profunde sulcati nitidi, ad basin sparse squamati; paleis eis rhizomatis similibus praediti. Rachides atropurpureae sulcatae non alatae, in sulco flavoceraceae aliter glabrae. Laminae 15–21 cm longae (7)11–20 cm latae papyraceae lanceolatae vel deltoideo-lanceolatae, ad basin obtusae, apice acuminatae, quadripinnatae interdum quadripinnato-pinnatifidae, sursum tripinnatae, apice pinnato-pinnatifidae; pinnis basalibus petiolulatis (usque ad 10 mm) oppositis vel suboppositis usque ad 11 cm longis 6 cm latis; pinnis superioribus petiolulatis (1–8 mm) 10–16 paribus alternis vel suboppositis usque ad 7 cm longis 4 cm latis; pinnis lanceolatis aequilateralibus anadromis, ad basin inferiorem excavatis, costis usque ad 0.75 mm diam. atropurpureis leviter sulcatis alatis (0.2–0.3 mm), pinnullis inaequilateralibus usque ad 11 mm longis 6 mm latis lanceolatis anadromis, ad basin inferiorem excavatis, usque ad 12 (16)-jugis 2–5 (15) mm distantibus, costulis usque ad 0.1 mm diam. atropurpureis leviter sulcatis alatis (0.1 mm), segmentis ultimis pinnato-lobatis plusminusve oblanceolatis et apice bifidis vel angustis et integris, venulis pinnatis in lobis terminantibus, paginis infra ceraceis aliter glabris, supra nitidis striatis glabris, margine integris et leviter revolutis. Sori dorsales supra venulas ultimas exindusiati, sporangiis subsessilibus. Sporae triletae, atrobrunneae.

Type: Near the Río Truando, 3–5 km above the airport at La Tere-sita, Depto. Chocó, Colombia, *Duke* 11200 (US; isotype NY).

Paratype: Quebrada with stream along the road to El Valle 8 km from Bahía Solano, Depto. Chocó, Colombia, ca. 50 m alt, *Lellinger & de la Sota* 97 (US; isoparatypes COL, LP).

Discussion: This species is most closely related to *P. pearcei* (Moore) Domin, from Costa Rica, Colombia, and Peru, but differs in having yellow wax and rather broader ultimate segments with 1, 2, or sometimes 3 veins, rather than lacking wax and the narrow ultimate segments with always a single vein.

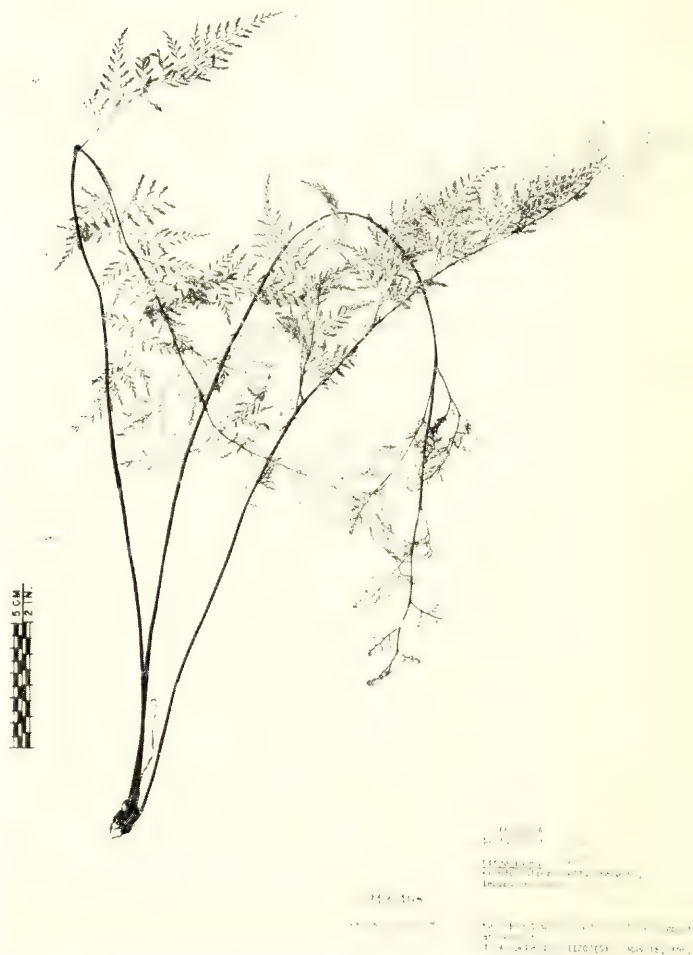


FIG. 4. Holotype of *Pityrogramma dukei* Lellinger, Duke 11200 (US).

Pleopeltis fructuosa (Maxon & Weath. in Weath.) Lellinger, comb. nov.

Polypodium fructuosum Maxon & Weath. in Weath. Contr. Gray Herb. 65:12. 1922. *Type*: Upper Caldera River, Holcomb's trail above Boquete, Pcia. Chiriquí, Panama, 1450–1650 m alt, Maxon 5689 (US).

Pleopeltis macrocarpa var. *complanata* (Weath.) Lellinger, comb. nov.

Polypodium lanceolatum var. *complanatum* Weath. Contr. Gray Herb. 65:8. 1922. *Type*: Juan Viñas, Pcia. Cartago, Costa Rica, *Pittier* 1855 (US).

Discussion: This variety is distinguished from var. *macrocarpa* by its flattened stipes and usually longer rhizome scales.

Pleopeltis wiesbaurii (Sodirol) Lellinger, comb. nov.

Drymoglossum wiesbaurii Sodirol, Anal. Univ. Quito 11(75):312. Aug. 1894. *Type*: Río Chimbo, Pcia. Guayas, Ecuador, 300–500 m alt, *Sodirol* (Hb. Sodirol not seen).

Polybotrya lourteigiana Lellinger, sp. nov.

Figure 5

Planta hemiepiphytica. Rhizoma scandens (0.5)1–1.5 cm diam. dense squamatum; paleis linearibus ca. 1–1.25 cm longis 1–1.5 mm latis leviter bicoloribus, parte centrali crassissima obscure brunnea, marginibus subtiliter ciliatis stramineis demum omnino erosis. Stipites (12)18–28 cm longi (2)2.5–6 mm diam. straminei profunde sulcati sparse pilosi primum, basi sparse squamati; paleis eis rhizomatis similibus sed marginibus stramineis latioribus praediti. Rhachides stramineae sulcatae hirtae praesertim in sulco; pilis ca. 0.5 mm longis ferrugineis. Laminae steriles coriaceae punctatae lanceolatae vel triangulares, ad basin truncatae vel obtusae, ad apicem acuminatae, 35–90 cm longae 22–60 cm latae tripinnato-pinnatifidae (bipinnato-pinnatifidae juventute) ad basin, sursum bipinnatae, ad apicem pinnato-pinnatifidae pinnatae vel pinnatifidae; pinnis 15–22 paribus alternis vel suboppositis; pinnis inferioribus petiolulatis bipinnatis, ad basin subaequalateralibus, usque ad 30 cm longis 12.5 cm latis; pinnulis ca. 10–13 paribus liberis, ad basin subaequalateralibus usque ad 7 cm longis 2 cm latis, costulis ca. 12-jugis, venis 4(5)-jugis; pinnis superioribus sessilibus vel adnatis lineari-lanceolatis, ad basin fere aequalateralibus, 2–12 cm longis 0.7–3 cm latis pinnatis pinnatifidis vel crenato-lobatis, marginibus crenatis vel integris, costis sulcatis, subtus glabris sed costis et venis hirtis, costulis usque ad 10-jugis, venis 1–3-furcatis. Laminae fertiles subtriangulares, ad basin obtusae, ad apicem acuminatae, ca. 50–75 cm longae 25–50 cm latae quadripinnatae; pinnis ca. 20 paribus alternis vel suboppositis lanceatis vel linearibus usque ad 29 cm longis 9 cm latis, costis sulcatis, hirtis, segmentis minutis.

Type: Trail along ridge from the confluence of the forks of the Río Mutatá above the Río Dos Bocas to the top of Alto del Buey, Depto. Chocó, Colombia, ca. 1450–1750 m alt. *Lellinger & de la Sota* 251 (US; isotypes COL, LP).



FIG. 5. Apical portion of the sterile frond of the holotype of *Polybotrya lourteigiana* Lellinger, Lellinger & de la Sota 251 (US).

Paratypes: Same locality as above, Lellinger & de la Sota 285 (US; isoparatypes COL, LP). Hillsides and base of the sheer, rock mountains, Mojarras de Tadó, 8.5 km E of Istmina, Depto. Chocó, Colombia, 150–250 m alt. Lellinger & de la Sota 387 (US; isoparatypes COL, CR, HUA, LP).

Discussion: The sterile laminae of this species resemble those of *P. villosula* Christ, but the much shorter and less stiff hairs that are particularly abundant on the rhachises and costae are unlike those of *P. villosula*. *Polybotrya loureigiana* also resembles some phases of *P. lechleriana* Mett., but has in general larger segments and lacks the generally stiff hairs found on the veins beneath in that species.

***Polybotrya pittieri* Lellinger, sp. nov.**

Figure 6

Planta hemiepiphytica. Rhizoma scandens (4)5–8 mm diam. dense squamatum; paleis linearibus ca. 8 mm longis 0.6 mm latis concoloribus vel leviter bicoloribus, parte centrali obscure brunneis, marginibus ciliatis ferrugineis demum omnino erosis. Stipites (18)27–45 cm longi 3–6 mm diam. straminei sulcati pilosi primum, ad basin squamati; paleis eis rhizomatis similibus praediti. Rhachides stramineae sulcatae pilosae; pilis ca. 0.15–0.70 mm longis stramineis. Laminae steriles coriaceae triangulares, ad basin abruptae, ad apicem acutae vel acuminatae, 45–60 cm longae 32–52 cm latae, ad basin bipinnato-pinnatifidae vel tripinnatae, sursum bipinnatae, ad apicem pinnato-pinnatifidae pinnatae vel pinnatifidae; pinnis ca. 20 paribus alternis vel suboppositis; pinnis inferioribus petiolulatis pinnato-pinnatifidis vel bipinnatis, ad basin aequilateralibus, 16–28(48) cm longis 6–8(19) cm latis, pinnulis ca. 12–16 paribus liberis, ad basin subaequalateralibus, usque ad 4.5(11) cm longis 2(3) cm latis, pinnulis abaxialibus pinnulas adaxiales superantibus, costulis ca. 8–12(16)-jugis, venis 3–6-jugis; pinnis superioribus petiolulatis vel sessilibus linearilanceatis, ad basin subaequalateralibus, 2–18 cm longis 0.6–5 cm latis, pinnato-pinnatifidis pinnatis pinnatifidis vel crenatis-lobis, marginibus integris, subtus glabris sed costis pilosis, costis sulcatis, costulis usque ad 12-jugis, venis 1–3-furcatis. Laminae fertiles triangulares, ad basin abruptae, apice acuminatae, usque ad 40(?) cm longae tripinnato-pinnatifidae; pinnis ca. 20(?) paribus alternis vel suboppositis lanceatis vel linearibus usque ad 17 cm longis 6 cm latis, costis sulcatis pilosis, segmentis minutis.

Type: Córdoba, Dagua Valley, Pacific Coastal Zone of the Depto. Cauca, Colombia, 30–100 m alt. *Pittier* 587 (US).

Paratypes: On both sides of the ridge of the Serranía de Los Paraguas, along the trail from El Cairo to Rio Blanco, ca. 8 km SW of El Cairo, Depto. Chocó–El Valle, Colombia, 2200–2250 m alt. *Lellinger & de la Sota* 843 (US). 0.3 km E of the road across the suspension bridge at ca. Km. 141 of the Ciudad Bolívar–Quibdó road, Depto. Chocó, Colombia, 750 m alt. *Lellinger & de la Sota* 899 (US; isoparatype LP). On both sides of the ridge W of La Mansa, Depto. Chocó–El Valle, Colombia, 2100–2200 m alt. *Lellinger & de la Sota* 948 (US).

Discussion: This species resembles most closely *P. osmundacea* Humb. & Bonpl. ex Willd., especially in the pilose axes, but differs from that



FIG. 6. Sterile frond of the holotype of *Polybotrya pittieri* Lellinger, Pittier 587 (US).

species in having the larger pinnules subequilateral at the base, and not strongly excavate at the lower base. Although it is like *P. lourteigiana* Lellinger in this character, it differs from that species in its rather stiffly pilose indument on the rhachis and costae, rather than a lax, hirtous indument.

Polypodium ambiguum Mett. ex Kuhn,
Linnaea 36:134. 1869, non Desv., 1827.

Lectotype: To fix the application of this name, I choose: Near Colonia Tovar, Edo. Aragua, Venezuela, *Fendler* 254 (US; isoelectotype B not seen). *Polypodium ambiguum* Mett. ex Kuhn, a nom. illeg., is a synonym of *P. ursipes* Moritz ex C. Chr.

Polypodium laxifrons var. *lividum* Kuhn ex Krug & Urban,
Bot. Jahrb. Engler 24:126. 1897.

Lectotype: To fix the application of this name, I choose: Mt. Guara-guao, Adjuntas, Puerto Rico, *Sintenis* 4328 (US). *Polypodium laxifrons* var. *lividum* is a synonym of *Grammitis asplenifolia* (L.) Proctor.

Polypodium loriceum f. *duplisorum* Domin, Pterid. Dominica 130. 1929.

Lectotype: To fix the application of this name, I choose: Heights of Aripo, Trinidad, *Broadway* 9957a (NY; isoelectotype US). The other syntypes are: Grenada, Sherring in 1890–91 (K? not seen); Mount Tocuche, Trinidad, *Britton, Hazen & Mendelson* 1324 (NY; isosyntype US); Trinidad, *Fendler* 83 in 1877–80 (US); and Trinidad, *Hart* 6771 (NY? not seen).

Discussion: This form probably does not deserve recognition, but should be considered a synonym of *P. loriceum* L.

Polypodium nicotianifolium Baker, Syn. Fil. 455. 1868.

Lectotype: To fix the application of this name, I choose: Mt. Chimborazo, Pcia. Chimborazo, Ecuador, *Spruce* 5723 (K not seen Tryon photo). The other syntype is: Chontales, Depto. Chontales, Nicaragua, *Seemann* 230 (K not seen Tryon photo); judging by the photograph, it may be a specimen of *Tectaria draconoptera* (D. C. Eaton) Copel.

Discussion: *Polypodium nicotianifolium* is a synonym of *Tectaria nicotianifolia* (Baker) C. Chr. The lectotype has the wavy, not or only slightly prominulous main lateral veins that are characteristic of that species.

Polypodium tablazianum Rosenst. Repert. Sp. Nov. Fedde 22:14. 1925.

Lectotype: To fix the application of this name, I choose: Cerro Carpintera, Pcia. Cartago, Costa Rica, 1500 m alt, A. & A. C. *Brade* 149 (S not seen photo 6080; isoelectotypes UC, US). The other syntypes are: Cerro Tablazo, Pcia. S. José, Costa Rica, 1900 m alt, A. & A. C. *Brade* 696 (S not seen; isosyntype NY not seen) and 1800 m alt, A. & A. C. *Brade* 14a (S not seen photo 6081). *Polypodium tablazianum* is a synonym of *P. alfredii* Rosenst.

Pteris longipetiolulata Lellinger, sp. nov.

Figure 7

Planta terrestris. Rhizoma breviter repens ca. 2 cm diam. squamatum; paleis lineari-lanceolatis ca. 3–5 mm longis 0.5–0.75 mm latis bicoloribus,



FIG. 7. Apical portion of the frond of the holotype of *Pteris longipetioliolata* Lellinger, Lellinger & de la Sota 739 (US).

parte centrali brunneo nitido rigido, parte marginali pallidiori laxo, marginibus erosis et irregulariter ciliatis. Stipites (0.5)1–3 m longi 3–5 mm diam. sulcati, ad basin atropurpurei, sursum fere straminei glabri, squamati; paleis eis rhizomatis similibus praediti. Rhachides stramineae non profunde sulcatae aculeatae, ad apicem squamatae; squamis lanceolatis

brunneis minutis et saepe similibus pilis deciduis. Laminae papyraceae vel coriaceae triangulari-deltaeidae, ad basin truncatae vel obtusae, ad apicem acutae, 0.3–1 m longae 0.3–1.25 m latae tripinnato-pinnatifidae, sursum bipinnato-pinnatifidae, ad apicem pinnatifidem decrescens; costis aculeatis squamatis, paleis eis rhachidis similibus praeditis; pinnis basalibus 0.15–0.5 m longis 0.25–0.65 m latis petiolulatis (usque ad 9 cm) lanceatis, ad basin parum inaequalateralibus, sursum aequalateralibus, ad apicem pinnatifidis caudatis, pinnulis 7–14 paribus suboppositis vel rare alternis, apice caudatis; pinnis suprabasalibus 5–25 cm longis 1.5–15 cm latis petiolulatis (usque ad 1.5 cm) vel subsessilibus lineari-lanceatis aequalateralibus, pinnulis vel segmentis 8–24 paribus oppositis vel suboppositis, ad apicem pinnatifidis caudatis, segmentis 5–20 mm longis 2–5 mm latis usque ad 7 mm distantibus, ad basin decurrentibus, ad apicem acutis vel mucronulatis, venulis usque ad 13-jugis 1–2 mm distantibus 0–2-furcatis liberis (venulis commissuralibus exceptis). Sori elongati indusiati; indusiis ca. 0.25 mm latis integris membranaceis pallidis.

Type: Principal ridge and slope 2 km E of San José del Palmar, Depto. Chocó, Colombia, 1550–1650 m alt, *Lellinger & de la Sota* 739 (US; isotypes COL, CR, HUA, LP).

Paratypes: “Canaan,” Mt. Purace, Depto. Cauca, Colombia, 3100–3300 m alt, *Pennell & Killip* 6623 (US). Páramos on the road from Bogotá to Calera, Depto. Cundinamarca, Colombia, *Woronov & Juzepczuk* 5142 (US).

Discussion: This species is related to *Pteris muricata* Hooker from which it differs in its larger size and much longer petiolules, especially on the basal pinnae. It is also much less pedate, with the basal pinnules of the basal pinnae subequal. Additional specimens of *P. longipetiolulata* in the U. S. National Herbarium are from other departments in Columbia (Magdalena, Santander, and Antioquia); all specimens of this species known to me have been found in the various ranges of the Andes from 2300 to 3500 m, with the exception of the type, which is also by far the largest specimen.

Selaginella estrellensis Hieron. Hedwigia 41:200. 1902.

Lectotype: Estrella, Pcia. Cartago, Costa Rica, 4400 ft alt, *J. J. Cooper* 6062 (US; islectotype B not seen), chosen by Alston (Bull. Brit. Mus. Nat. Hist. 1:249. 1955). Other syntype is: Near La Carpintera, Pcia. Cartago, Costa Rica, *Pittier & Tonduz* 48 (B not seen; pre-sumable isosyntype “*Pittier 118*” US).

Selaginella wendlandii Hieron. in Engl. & Prantl, Nat. Pflanzenfam. 1(4):683. 1901.

Lectotype: The original publication mentioned no types. Several syntypes are cited in a later paper by Hieronymus (Hedwigia 41:186. 1902). From among these I choose: Near San Miguel, Costa Rica,

Wendland 771 (B not seen). The other syntypes are from Guatemala: Near Pansamalá, Depto. Alta Verapaz, 1300–1400 m alt, *von Tuerckheim* 679 (B not seen; isosyntype US); and between Santa Cruz Almor and Ixcán, Depto. Huehuetenango, Sept 1876, *Bernoulli* (B not seen). *Selaginella wendlandii* is a synonym of *S. oaxacana* Spring.

Stigmatopteris clypeata (Maxon & Morton) Lellinger, comb. nov.

Dryopteris clypeata Maxon & Morton, Bull. Torrey Bot. Club 66:52. 1939. *Type*: Hills back of Puerto Obaldía, Com. S. Blas, Panama, 50–200 m alt, *Pittier* 4309 (US).

Discussion: This species is known only from the type.

Stigmatopteris killipiana Lellinger, sp. nov.

Figure 8

Planta terrestris. Rhizoma breviter repens 0.5–1 cm diam. squamatum; paleis lineari-lanceolatis ca. 3–5 mm longis 1–1.5 mm latis concoloribus rufobrunneis vel castaneis nitidis rigidis, marginibus integris. Stipites ca. 50 cm longi 3–5 mm diam. sulcati sparse squamati, subtus atropurpurei vel brunnei, supra fere straminei; paleis in dimidio inferioris stipitum eis rhizomatis similibus praediti; paleis in dimidio superioris stipitum eis rhachidis similibus praediti. Rhachides stramineae vel brunneae, supra sulcatae, in sulco pilosae, squamatae; paleis linearibus usque ad 5 mm longis 0.5 mm latis stramineis. Laminae papyraceae triangulares, ad basin truncatae vel obtusae, ad apicem acutae, 38–53 cm longae 24–31 cm latae pinnatae sursum pinnatifidae, ad apicem pinnatifidae vel lobatae; pinnis et lobis ascendentibus, marginibus crenatis vel integris, ad basin obtusis basi inferiore excavatis, ad apicem crenatis subcaudatis, glabris; pinnis inferioribus petiolulatis (usque ad 4 mm) 3–5 paribus oppositis vel suboppositis 10–15 cm longis 2.5–4.5 cm latis lineari-lanceolatis vel rare ovato-lanceolatis, costulis 18–25(30)-jugis 4–7 mm distantibus, venis usque ad 7 paribus anastomosantibus, venulis liberis excurrentibus 1 vel 2; pinnis superioribus adnatis 2–4 paribus suboppositis vel alternis 7–12.5 cm longis 1.25–2.5 cm latis lineari-lanceolatis vel subquadratis, costulis 16–20(22)-jugis 2.5–3.5 mm distantibus, venis usque ad 5(6) paribus anastomosantibus, venulis liberis excurrentibus 1 vel 2. Sori exindusiati usque ad 8 singulariter vel in paribus inter costulas rotundati leviter elongati vel interdum confluentes, receptaculo non elevato.

Type: Hillside above the Río Mutatá ca. 3 km above its junction with the Río El Valle, near Alto del Buey, Depto. Chocó, Colombia, ca. 850 m alt, *Lellinger & de la Sota* 194 (US; isotypes COL, CR, HUA, LP).

Paratypes: Trail along ridge from the confluence of the forks of the Río Mutatá above the Río Dos Bocas toward the top of Alto del Buey, Depto. Chocó, Colombia, ca. 950–1450 m alt, *Lellinger & de la Sota* 221 (US; isoparatypes COL, LP). Deep ravine near Frijoles, Canal Zone,



FIG. 8. Holotype of *Stigmatopteris killipiana* Lellinger, *Lellinger & de la Sota* 194 (US).

Panama, *Killip* 2919 (US). Between Frijoles and Monte Lirio, Canal Zone, Panama, 30 m alt, *Killip* 12147 (US).

Discussion: This species differs from *S. allooptera* (Kunze) C. Chr. in having pinnae that are exavate at the lower base and slightly decur-

rent, rather than not excavate and strongly decurrent and from *S. opaca* (Baker) C. Chr. (syn. *Dryopteris christii* C. Chr.) in having usually discrete rather than meniscioid sori.

Trichomanes eximium var. *crispulum* Rosenst.

Repert. Sp. Nov. Fedde 20:89. 1924.

Lectotype: To fix the application of this name, I choose: Organ Mountains, Est. Rio de Janeiro, Brazil, *Luetzelburg* 6196 (US; isolectotype M not seen). Rosenstock cited six other syntypes from the area, all Luetzelburg collections and all deposited at M. *Trichomanes eximium* var. *crispulum* is a synonym of *T. diaphanum* H.B.K.

PROCEEDINGS
OF THE
BIOLOGICAL SOCIETY OF WASHINGTON

THE CRAYFISH *BOUCHARDINA ROBISONI*, A NEW
GENUS AND SPECIES (DECAPODA, CAMBARIDAE)
FROM SOUTHERN ARKANSAS

BY HORTON H. HOBBS, JR.

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The first specimen obtained of the crayfish described herein was collected from backwaters of Bayou Bodcaw, a tributary of the Red River, in Lafayette County, Arkansas, on 13 June 1974 by "unnamed high school students." It was forwarded to me along with other crayfishes from the southern part of the State by Henry W. Robison. Believing this specimen, a second form male, to be a member of an undescribed species of the genus *Hobbseus*, I requested Dr. Robison to attempt to secure additional material. In spite of efforts made by him, not until 26 April 1976, when a cooperative expedition was made by Dr. Robison, Raymond W. Bouchard, Michael T. Kearney, and me to collect specimens in the area where the first one had been caught, was a series containing first form males obtained. The four of us working with two seines for 2½ hours netted 150 crayfishes, 40 of which were members of the new species described below. Because of the small size of the individuals that were secured, I was not certain that we had found members of the same species that had been discovered earlier until I returned to Washington some 10 days later. None of the specimens are appreciably larger than members of the genus *Cambarellus* that frequent the same ditch.

For reasons discussed below (see "Relationships"), this small crayfish is assigned to a new genus named in honor of my friend, Raymond W. Bouchard, a fellow student of the crayfish who was indirectly responsible for my receiving the

first specimen of this new species and who aided in collecting the type-series.

I am most grateful to those persons mentioned above for their assistance in amassing the collection available to me. Thanks are extended also to Thomas E. Bowman, Margaret A. Daniel, and Isabel Pérez Farfante, all Smithsonian colleagues, for their criticisms of the manuscript.

Bouchardina, new genus

Diagnosis: Antenna never with conspicuous fringe of setae on mesial border. Third maxilliped with teeth on mesial margin of ischium. Length of mesial margin of palm of chela of male subequal to that of dactyl and with single irregular row of 11 to 18 small corneous denticles (traces of second row sometimes present); opposable margin of both fingers in male entire and lacking conspicuous tubercles but studded with band of minute denticles; corresponding margins of fingers in female with few tubercles and single row of denticles. Areola 2.0 to 2.6 times as long as wide and constituting 25.2 to 29.5 percent of entire length of carapace (35.1 to 37.3 percent of postorbital carapace length). Ischium of third pereopod of male with slender hook; coxae of fourth and fifth pereopods lacking caudomesial boss. First pleopods of first form male symmetrical, shallowly withdrawn in sternum, bearing proximomesial spur, and terminating in 2 parts, neither conspicuously longer than other; mesial process broad at base, tapering rapidly to slender acute tip directed caudally and somewhat distomesially at 50 to 60 degrees to axis of appendage; central projection with antero-posterior plane broad, comparatively short, bladelike, and tilted caudomesially at about 50 degrees to main axis of appendage. Female with annulus ventralis freely movable; first pleopod absent. Branchial count 17 + epipodite.

Gender: Feminine.

Type-species: *Bouchardina robisoni*, new species.

Range: Known only from the type-locality of *B. robisoni* in Lafayette County, Arkansas.

Bouchardina robisoni, new species

Diagnosis: Same as that for genus.

Holotypic Male, Form I (several figures cited are from paratypes, see legend): Eyes large and pigmented. Cephalothorax (Fig. 1a, g) subovate, slightly compressed, and highest short distance cephalic to cervical groove. Abdomen narrower than thorax (4.6 and 5.3 mm). Greatest width of carapace slightly anterior to midlength of areola. Areola 2.1 times as long as wide, with few punctations, and constituting 26.1 percent of entire length of carapace (35.9 percent of postorbital carapace

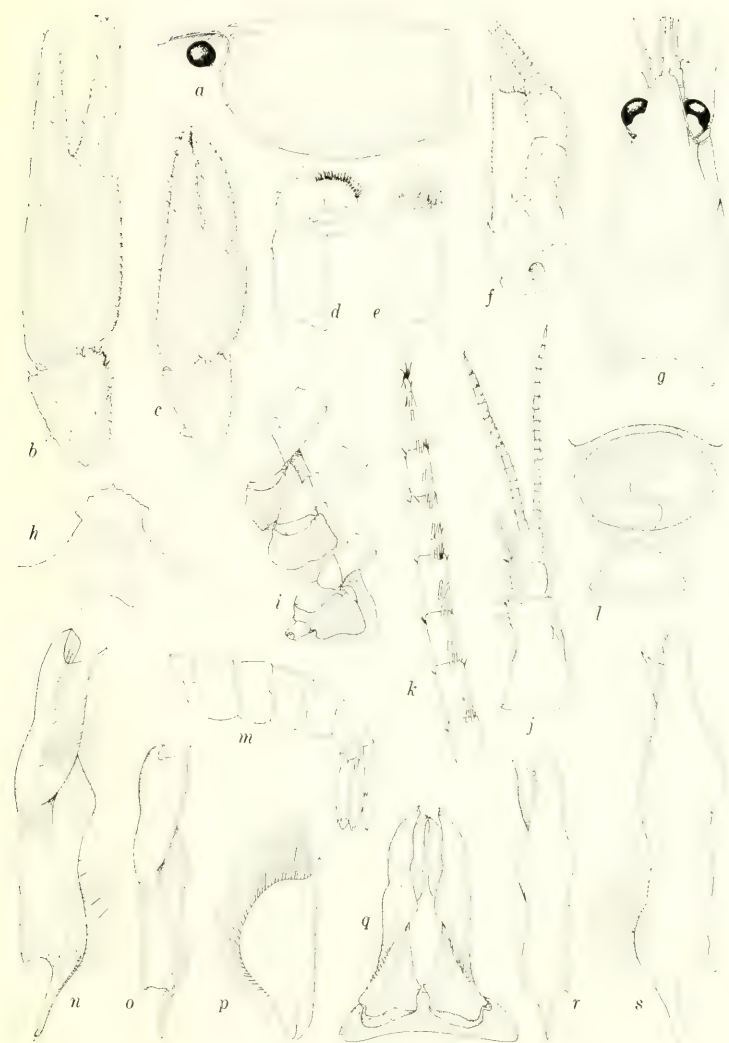


FIG. 1. *Bouchardina robisoni*, new species (a, b, g, h, i, m, n, s, from holotype; l, from allotype; o, r, from morphotype; c-f, j, k, p, from paratype female; q, from paratype male). a, Lateral view of carapace; b, c, Dorsal view of distal podomeres of cheliped; d, e, Pre- and postaxial view of mandible, respectively; f, Ventral view of proximal part of antenna; g, Dorsal view of cephalothorax; h, Epistome; i, Basal podomeres of third, fourth, and fifth pereopods; j, Ventral view of antennule; k, Ventral view of distal articles of lateral ramus of antennule; l, Annulus ventralis; m, Lateral view of abdomen; n, o, Mesial view of first pleopod; p, Antennal scale; q, Caudal view of first pleopod; r, s, Lateral view of first pleopod.

length). Rostrum subplane dorsally with sparse pubescence and with elevated but unthickened, slightly convex lateral margins, latter suddenly contracted about level of midlength of penultimate podomere of peduncle of antennule, forming short acumen, tip of which slightly overreaching proximal margin of ultimate podomere. Subrostral ridge evident in dorsal aspect almost to base of acumen. Postorbital ridge somewhat concave mesially, with lateral groove, and terminating cephalically in acute spine. Suborbital angle obtuse but distinct. Branchiostegal spine acute and well developed. Surface of carapace mostly punctate and studded with fine setae; cervical spine absent.

Cephalic lobe of epistome (Fig. 1*h*) subtriangular with elevated, irregularly emarginate cephalolateral borders and with cephalomedian acute prominence; main body with broad cephalomedian depressed area, and bearing arched epistomal zygoma. Antennular peduncle (Fig. 1*j*) with strong acute spine on mesioventral margin distal to midlength of basal podomere; lateral flagellar ramus with distal 9 articles bearing aesthetascs as illustrated (Fig. 1*k*). Antenna extending caudally to base of telson. Antennal peduncle (Fig. 1*f*) with lateral spine on basis and ischium. Antennal scale (Fig. 1*p*) 2.4 times as long as wide, broadest slightly proximal to midlength, with strong acute spine distolaterally, latter exceeding distal extremity of antennal peduncle.

Third maxilliped extending cephalically to midlength of basal podomere of antennular peduncle; ischium with subacute teeth, mesial half with conspicuous stiff setae, lateral half with usual submarginal row of finer plumose setae, and distolateral angle subtruncate; exopod reaching end of proximal third of carpus.

Abdomen longer than carapace (11.4 and 10.7 mm). Pleura (Fig. 1*m*) rounded to subtruncate ventrally, only caudoventral part of fourth and sixth subangular. Cephalic section of telson with 2 spines in each caudolateral corner.

Left chela (right regenerated) (Fig. 1*b*) slender, elongate, 3.6 times as long as greatest width, subovate in cross section, and with fingers subequal in length to mesial margin of palm. Mesial surface of palm with row of 13 small, irregularly situated, corneous tubercles; dorsal surface studded with squamous tubercles; all surfaces with stiff setae interspersed among more numerous, shorter, plumose ones. Fingers with longitudinal ridges virtually obsolete; opposable surfaces of both with broad longitudinal band of minute denticles and lacking well defined tubercles; other surfaces of fingers similar to that of palm with proportionately many more stiff setae.

Carpus of left cheliped longer than broad with small squamous tubercles, except ventrally, and provided with conspicuous setae, especially along dorsodistal margin; dorsal mesiodistal angle with acute spine, mesiodistal margin with another, and third one present on podomere adjacent to distal ventrolateral articular knob. Merus with group of spiniform tubercles dorsally on distal fourth, 2 larger than others; ventral surface with rather dense plumose setal mat flanked mesially by

longitudinal row of 11, mostly acute, tubercles, and laterally by 1 large spine and 2 or 3 very weak tubercles proximal to it; laterodistal articular area supporting additional small acute tubercle. Ventromesial surface of ischium with 1 moderately large tubercle and several other poorly defined ones; sufflamen present.

Hook on ischium of third pereopod (Fig. 1i) simple, slender, arched, and slightly overreaching distal end of basis. Sternum between coxae of second, third, and fourth pereopods moderately deep, bearing fringe of plumose setae ventrolaterally, latter not obscuring first pleopod when in resting position.

First pleopods (Fig. 1n, q, s) as described in "Diagnosis." Subapical setae lacking but others present as illustrated. Basal segment of uropod with acute spine on each lobe; mesial ramus with distomedian spine not reaching distal margin of ramus.

Allotypic Female: Differing from holotype in following respects: margins of rostrum more strongly arched, almost lacking angles at base of acumen; subrostral ridges not evident in dorsal aspect anterior to level of eyes. Fingers of chela distinctly longer than mesial margin of palm; opposable margin of fixed finger with 3 corneous tubercles along proximal half of finger, distalmost largest; corresponding surface of dactyl with single corneous tubercle opposite gap between second and third tubercles on fixed finger, minute denticles forming single row on both fingers; remaining podomeres of cheliped markedly similar to those of holotype although some tubercles much less well developed.

Annulus ventralis (Fig. 1l) subelliptical with horizontal diameter about 1.5 times that of longitudinal; ventral surface not strongly contoured but with distinct troughlike depression extending caudodextrally from midcephalic region; greatest height occurring in transverse broadly rounded elevation situated on caudosinistral side of depression; sinuous sinus strongly tilted to left, originating in oblique depression dextral to median line and slightly caudal to midlength, coursing caudosinistrally across median line before making sudden turn caudally, cutting caudal margin of annulus short distance sinistral to median line. Postannular sclerite subtriangular, its width subequal to length of annulus and its length almost two-thirds that of annulus. First pleopod lacking.

Morphotypic Male, Form II: Differing from holotype in following respects: rostrum with margins more strongly arched, resembling that of allotype; subrostral ridges evident dorsally only in basal orbital region; left postorbital ridge with cephalic extremity almost truncate, right with small tubercle; branchiostegal spines rudimentary; mesial margin of palm of chela with row of about 17 small sclerotized tubercles; all tubercles of more proximal podomeres of cheliped reduced, conspicuous one on ventrolateral surface of merus in holotype represented by tubercle no larger than others nearby; hook on ischium of third pereopod greatly reduced. First pleopod (Fig. 1o, r) differing little from that of holotype except for noncorneous texture and slight inflation of central projection.

TABLE 1. Measurements (mm) of *Bouchardina robisoni*.

	Holotype	Allotype	Morphotype
Carapace:			
Entire length	10.7	12.2	16.6
Postorbital length	7.8	9.4	11.4
Width	5.3	6.5	8.7
Height	5.1	5.2	6.4
Areola:			
Width	1.3	1.7	1.9
Length	2.8	3.4	4.3
Rostrum:			
Width	1.4	2.4	3.0
Length	1.8	2.9	3.4
Chela:			
Length, mesial margin of palm	2.8	1.9	3.2
Width of palm	3.2	2.0	4.4
Length of lateral margin	6.6	4.9	8.8
Length of dactyl	3.0	2.7	3.6
Abdomen:			
Width	4.6	5.4	6.1
Length	11.4	13.1	16.7

Color Notes: General tone grayish tan over cephalothorax and cephalic part of abdomen, fading caudally, with telson and uropods pale gray. In more detail, dorsum of cephalic section of carapace pale reddish tan; lateral surface bearing paired almost U-shaped rust markings, bases of which abutting orbit, with one arm extending caudally, flanking postorbital ridge and turning dorsomesially and ending in dark spot slightly posterior to midlength of gastric region; other arm of "U" straight, and, lying on level slightly dorsal to junction of 2 segments of cervical groove, ending in dark spot adjacent to cervical groove; cephalic area between suborbital angle and branchiostegal spine cream white. Branchiostegites with conspicuous, paired, dark reddish brown dorsolateral longitudinal stripes originating at cervical groove and continuing caudally to second abdominal tergum; in addition, paired cream white longitudinal stripes situated laterally and 2 or 3 conspicuous dark brown spots present cephaloventrally, interspersed with irregular cream white markings; latter also flanking ventral margin of branchiostegites to caudal margin. Dorsolateral dark brown stripe on branchiostegite continuing onto abdomen where almost black on first abdominal tergum, fading slightly on second, and becoming broken on succeeding terga where represented by short,

cephalically situated segments; latter progressively smaller and paler caudally, that on sixth barely perceptible. Reduced first abdominal pleuron white; each succeeding pleuron bearing large, subtriangular reddish black spot. Dorsum of all terga suffused with rust between dark linear series of "segments," very dark on first tergum and fading caudally to base of telson, nevertheless intensifying caudally on each of second through sixth terga. Telson and uropods mostly pale but former with cephalomedian dark spot and paired ones at caudolateral corners of cephalic section. Peduncles of antennule and antenna pale gray mottled with rust spots, some of which forming lines laterally and along dorso-distal margins of podomeres; antennal scale with gray stripe along lateral margin. Chelipeds largely grayish tan but with dorsally situated rust markings on distal part of merus, over much of dorsal and dorso-mesial part of carpus, and forming line along mesial margin of palm of chela; distal extremities of fingers of chela very pale. Remaining pereopods faintly mottled with rust or gray over pale gray.

Type-locality: Backwaters of Bayou Bodcaw (Red River Basin) in borrow ditch along Sunray Road, 4 miles (6.4 km) north of Lewisville, off State Route 29, Sec. 14, R. 24W, T. 15S, Lafayette County, Arkansas. The body of water in the ditch varied in width from about 2 to 7 meters, and in the area where this crayfish was found was no more than 0.5 meter deep. The bottom consisted largely of sandy clay overlain by decaying leaves. At the time the collection was made on 26 April 1975, the water was somewhat cloudy, and *Ludwigia* sp., *Utricularia* sp., and grasses (particularly the latter) were conspicuous aquatic plants in the vicinity of where the specimens were taken. The dominant shoreline trees were members of the genera *Pinus* and *Quercus*. *Crataegus* sp. was also abundant. Occurring in the ditch with *Bouchardina robisoni* were four other crayfishes: *Cambarellus* sp., *Cambarus* (L.) *diogenes* subsp., *Procambarus* (G.) *tulane* Penn (1953:163), and *Procambarus* (O.) *geminus* Hobbs (1975:1).

Disposition of Types: The holotypic male, allotypic female, and morphotypic male, numbers 147146, 147147, 145743, respectively, are deposited in the National Museum of Natural History (Smithsonian Institution). The paratypes, of which some of the second form males are being retained alive (anticipating a molt to first form), are in the Smithsonian Institution and the collection of Raymond W. Bouchard.

Range and Specimens Examined: Known only from the type-locality—1 ♂ II, 13 June 1974, collectors unnamed; 1 ♀, 25 April 1976, R. W. Bouchard, coll.; 4 ♂ I, 12 ♂ II (2 molted to first form in June and July), 24 ♀, 26 April 1976, R.W.B., H. W. Robison, M. T. Kearney, and H. H. H., Jr., coll.

Variations: The most conspicuous variations noted are those associated with the rostrum and chela. There is evidence that the young of this species bear well defined marginal spines on the rostrum which become smaller with age; in the largest specimens there is hardly a trace of even an emargination at the base of the acumen. Not correlated with

size or age of the specimen is a rather striking difference in the subrostral ridges. In some specimens, they are visible in dorsal aspect from the orbit to the base of the acumen; in others, they cannot be seen except in the caudalmost part of the orbit; in the majority, they disappear beneath the rostral margin posterior to midlength of the rostrum. The strong dimorphism in the chelae of the males and females was noted in the above descriptions, a difference which not only involves the much longer palm in the male but also the arrangement of the denticles on the opposable surfaces of the fingers. In the smaller second form males, the denticles on the fingers are arranged in a single row, as they are in the female; in the morphotypic male, the largest specimen available, however, there is a band of denticles along both fingers; in none of the males are there well defined tubercles on these surfaces although in some there are sclerotized patches among the denticles which seem to occur in areas corresponding to the positions of tubercles on the chelae of the females. The distribution of tubercles along the mesial half of the palm of the chela may not be so variable as seems apparent. Because of the pilosity and small size of the chelae, it is likely that some of the tubercles are being overlooked. In all of them, there is one row of small sclerotized tubercles along the mesial margin of the palm; in the largest specimen, the morphotype, there are 18 tubercles; in none of the others does there appear to be more than 13 or fewer than 8. In one of the first form male paratypes, a second irregular row of tubercles flanks the dorsolateral side of the mesial one, and other tubercles lie between and proximo-mesial to the 2 rows. A first form male as large as the morphotype is needed to determine the precise nature of the arrangement of the tubercles.

While there are variations in the annulus ventralis and postannular sclerite, most appear to be associated with the size of the female and/or degree of calcification of these structures. In the majority of the smaller specimens, for example, the differences in surface relief of the annulus is much less marked than in the larger females.

For differences noted in proportions, see Table 1 and the "Diagnosis."

Size: The largest specimen available is a second form male which has a carapace length of 16.6 mm (postorbital carapace length 11.4 mm). Corresponding lengths of the largest and smallest first form males are 11.2 (8.5) and 10.7 (7.8) mm; those of the largest female are 13.4 (9.9) mm.

Life History Notes: The only data available include the occurrence of first form males on April 26, and, among the second form males obtained at that time, one molted in the laboratory to first form on June 3, and another did likewise during July. Neither ovigerous females nor ones carrying young have been found.

Relationships: The relatively small size of this cambarine suggests a close affinity between it and members of the genera *Faxonella* and *Hobbsseus* (see Hobbs, 1974:12-14) to both of which it is certainly allied, but it also shares certain characters with members of the genus

Orconectes. As pointed out above, when initially I examined the single second form male sent to me by Dr. Robison, I tentatively assigned it to the genus *Hobbseus*, chiefly because of the 2 short rami on the first pleopod and the single row of sclerotized tubercles along the mesial margin of the palm of the chela. The absence of any visible rudiment of bosses on the coxae of the fourth pereopods also supported the tentative generic assignment. A possible close kinship to the 3 members of the genus *Faxonella* seemed unlikely in view of the fact that the rami of the first pleopod were not only short but also subequal in length.

When the first form male and the female became available, the original generic assignment became untenable. The first pleopod, instead of resembling that of either *Faxonella* or *Hobbseus*, was more similar to those of certain members of the genus *Orconectes* (for example, *O. i. inermis* Cope (1872), *O. difficilis hathawayi* Penn (1952), *O. sloanii* (Bundy, 1876), and *O. kentuckiensis* Rhoades (1944)). The slender curved hook on the ischium of the third pereopod is more similar to that of species of the genus *Faxonella* and the troglobitic *Orconectes* than to those of *Hobbseus*. The annulus ventralis is freely movable as it is in the 3 just-mentioned groups, except in the more advanced *Orconectes* (*O. d. hathawayi*, *O. sloanii*, and *O. kentuckiensis*). It differs from the primitive (troglobitic) *Orconectes* in lacking a prominent boss on the coxa of the fourth pereopod, in this respect resembling the members of *Faxonella* and *Hobbseus*. From *Faxonella*, it differs primarily in the structure of the first pleopod of the male and in the annulus ventralis of the female; despite the similar attitude of the rami of the pleopod, the difference in their lengths is comparatively slight, not one long and the other short as in *Faxonella*, and the ventral surface of the annulus ventralis is decidedly less complexly sculptured.

From *Hobbseus*, it differs primarily in the form of the central projection of the first pleopod; while the inclination of this ramus is similar to that of *H. orconectoides* Fitzpatrick and Payne (1968), its broad, short, bladelike form is strikingly different from the comparatively long, tapering, acute corresponding element in all members of the genus *Hobbseus*. Moreover, there is no caudomesial boss on the coxa of the fifth pereopod as is typical of members of the latter genus.

The annulus ventralis, while far less complexly sculptured than in members of *Faxonella*, resembles those of members of the latter at least as closely as it does those of members of the genus *Hobbseus*.

Because of the unique combination of characters pointed out above, I am proposing that it be assigned to the monotypic genus *Bouchardina*, the ancestors of which must have been derived from the archiorconectoid line (Hobbs, 1969:119), the same as that from which the members of *Faxonella*, *Hobbseus*, and *Orconectes* were postulated to have arisen.

Etymology: This crayfish is named in honor of Henry W. Robison who not only sent the first specimen of this crayfish I had seen to the Smithsonian Institution, but who has also added numerous crayfishes to

the national collection as well as assisted in securing the series of specimens obtained in April.

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PROCEEDINGS
OF THE
BIOLOGICAL SOCIETY OF WASHINGTON

THREE NEW SPECIES OF THE NEOTROPICAL
WATER BEETLE GENUS *ELMOPARNUS*
(COLEOPTERA: DRYOPIDAE)

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Members of the dryopid genus *Elmoparnus* are rare in collections and only three species have been described in the 84 years since the genus was described. The type of the genus, *E. brevicornis* Sharp (1882), was described from a single male collected in Panama. The second species known, *E. glaber* Grouvelle (1889), was described from a male and two female specimens from Venezuela. The third species, *E. mexicanus* Brown (1970b), was described from a single female from Mexico.

The early descriptions of *E. brevicornis* by Sharp and *E. glaber* by Grouvelle were brief and incomplete but these deficiencies were corrected in a synopsis of the genus by Hinton (1940) in which he redescribed both species, extended the generic diagnosis to make it comparable with modern generic descriptions, and discussed the distribution of the few specimens available to him at the time.

Since Hinton's synopsis appeared, only two articles referring to the genus have been published. The first reference was its inclusion in a key to the dryopid genera of the New World and a brief mention of its habitat by Brown (1970a). The second article was a description of the new species, *E. mexicanus* Brown (1970b) with comments on its habitat and a key to the three species known at that time.

During the past few years several additional collections of

Elmoparnus were made by M. E. and P. D. Perkins in Mexico and Central America, C. M. and O. S. Flint, Jr. in Venezuela, P. J. Spangler et al. in Ecuador, and A. Langley et al. in Ecuador. Among the 18 specimens included in this recently acquired material we recognize one previously described species, *E. glaber*, and three new species. Therefore, we have prepared this article to describe the new species and to present some new information regarding this poorly known but exceedingly interesting genus of beetles.

***Elmoparnus pandus*, new species**

Figures 1, 3-5, 7-16, 19, 20

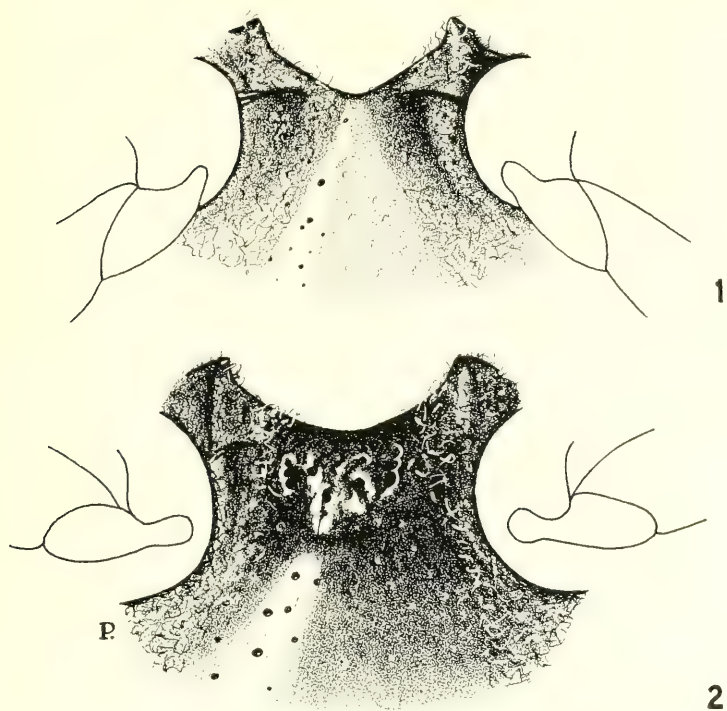
This new species is similar to *E. brevicornis* Sharp, *E. mexicanus* Brown, and *E. miltops*, new species, because all four species have 9-segmented antennae. However, *E. pandus*, new species, may be distinguished from *E. brevicornis* by the sublateral pronotal carina extending from base to apex instead of being restricted to the basal two-fifths. From *E. mexicanus*, *E. pandus* may be distinguished by the following characters: its smaller size, 3.5 mm vs. 5.6 mm; punctures on pronotal disc separated by one to two times their diameter instead of two to four times; first abdominal sternum not feebly rugose laterally; and labrum and clypeus light reddish brown.

From *E. miltops*, which it closely resembles, *E. pandus* may be distinguished by the form and sculpture of the anteromedial region of the metasternum, which is narrow, very slightly elevated, and possesses small widely separated punctures (Fig. 1) instead of being wide, distinctly elevated, and with coarse, sometimes confluent punctures (Fig. 2). In addition the posterior coxae of *E. pandus* are less densely and less coarsely punctate than the posterior coxae of *E. miltops*.

Holotype male: Length 3.5 mm; width 1.7 mm. Body form obovate, moderately strongly convex dorsally. Color dark reddish brown; pronotum darker than elytra; antennae, clypeus, and labrum light reddish brown. Venter dark reddish brown except all palpi, labium, apical margin of prosternum, tibiae, tarsi, and apex of last abdominal sternum lighter reddish brown.

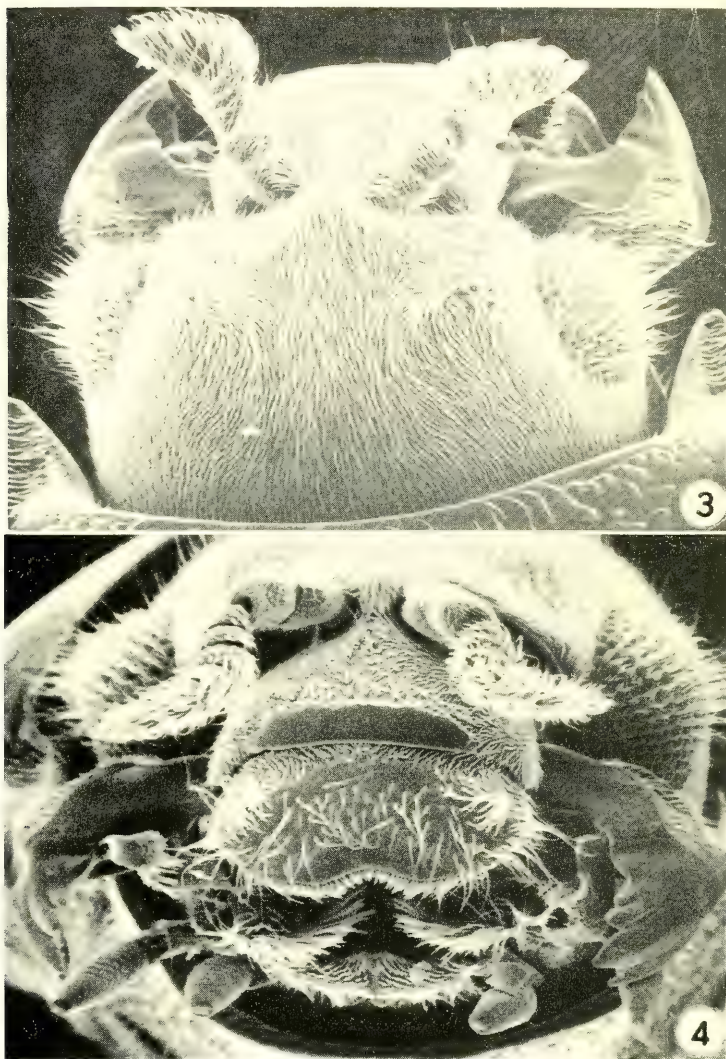
Head finely microreticulate, micropunctate, and densely pubescent (Figs. 3, 4) except anterior edge of clypeus glabrous. Eyes with large convex facets also pubescent. Antenna 9 segmented (Fig. 5). Labrum shallowly emarginate anteromedially; emargination bordered by a glabrous liplike area; upper edge of liplike area sharply, angularly demarcated; labral surface above liplike area densely microreticulate, with numerous long, golden, upswept setae dorsolaterally resembling a mustache; anterolateral angles broadly rounded.

Pronotum 1.0 mm long; 1.5 mm wide, widest at base; sides arcuate; anterior side feebly margined; lateral sides strongly and distinctly mar-



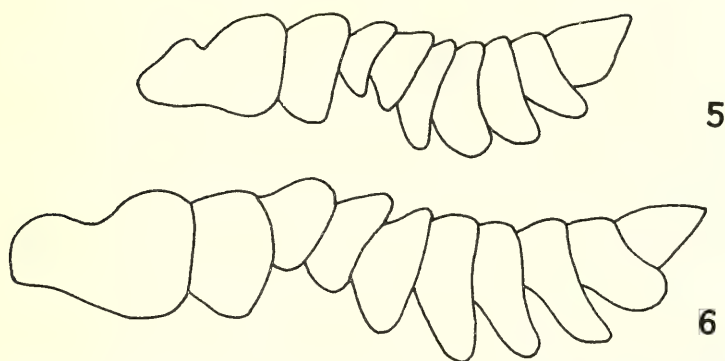
FIGS. 1 & 2. Intercoxal area of metasternum: 1, *Elmoparnus pandus*, new species; 2, *E. miltops*, new species.

gined; posterior side not margined but strongly bisinuate; anterolateral angles strongly produced, apex acute; sublateral carinae distinct, extending from base almost to apex at each anterolateral angle; diverging so that each carina at apex is only about one-half as far from lateral margins as at base. Coarse and fine punctures intermixed and denser between sublateral carina and lateral margin. Disc with coarse (at $100\times$), moderately dense punctures; punctures separated by their diameter; punctures coarser and sparser adjacent to sublateral carina. Prosternum with inclined sides densely pubescent; medial surface flat, glabrous, and coarsely sparsely punctate; punctures denser along apical margin, separated by about one-half to one times their diameter. Prosternal process (Fig. 7) flat, broad, widening slightly between procoxae; sides feebly margined, arcuate, converging apically, and terminating in a slender protuberance (Fig. 8); surface glabrous, sparsely and moderately coarsely punctate; punctures separated by two to four times their diameter, denser and coarser laterally. Mesosternum deeply foveate (Fig. 9) for recep-



FIGS. 3 & 4. *Elmoparnus pandus*, new species, head: 3, Dorsal view, 110 \times ; 4, Facial view, 100 \times .

tion of protuberance of prosternal process. Metasternum with antero-medial region narrow, slightly raised above plane of posterior region (Fig. 1); inclined sides densely pubescent; medial surface flat, almost glabrous, with shallow longitudinal furrow on midline, and punctate;



FIGS. 5 & 6. Antenna (pubescence omitted): 5, *Elmoparnus pandus*, new species; 6, *E. dasycheilus*, new species.

punctures moderately fine, sparse along furrow but slightly denser antero-medially between mesocoxae. Metacoxa sparsely and moderately coarsely punctate. Foreleg with tibia evenly arcuate from base to apex (Fig. 10) and a distinct notch at apical fourth (Fig. 11); foretibia bearing a dense, narrow tuft of moderately long golden setae along posteromedial edge, tuft extends distad about one-half length of tibia. Protarsal segments 1 to 3 expanded and bearing a large oblique row of dense, flat, golden setae on medial surface (Fig. 12).

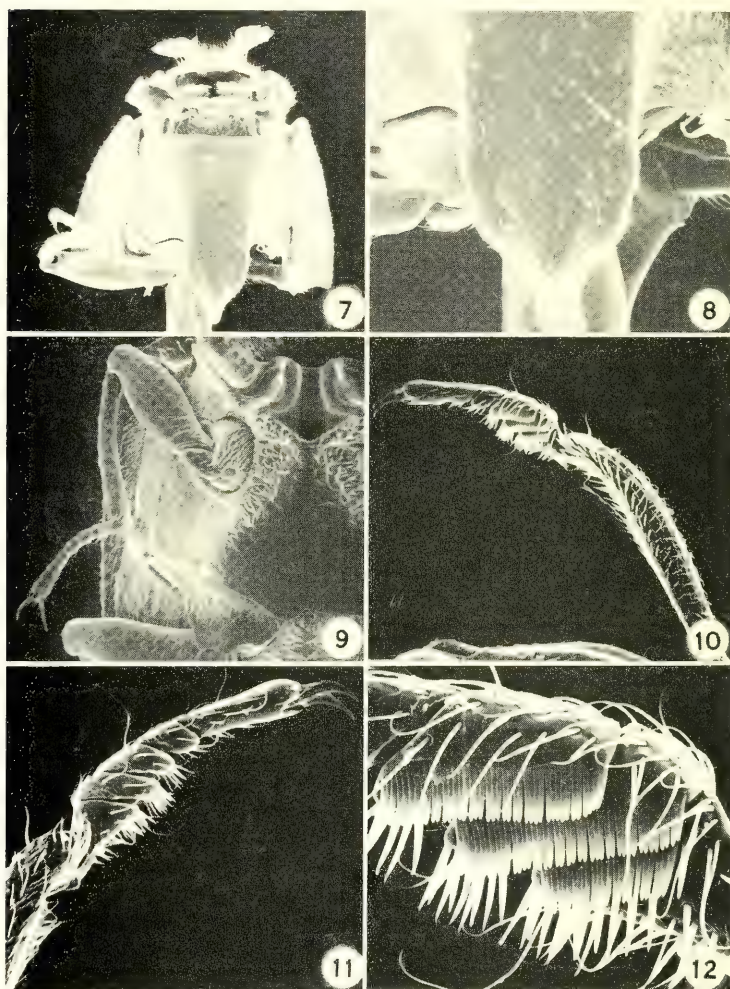
Scutellum flat, subtriangular, rounded laterally; surface finely, sparsely punctate, punctures separated by about three to four times their diameter.

Elytra punctate. Punctures coarser and denser than those on pronotal disc, and although mostly disarrayed, three poorly defined serial rows of smaller punctures are evident adjacent to suture; slightly coarser disarrayed punctures in intervals; punctures in serial rows separated by one-half to three times their diameter, those in intervals separated by one to six times their diameter. Lateral margin of each elytron with a densely pubescent respiratory fovea at about apical fourth (Figs. 13, 14). Sides of elytra rather evenly arcuate from base to apex; sides rather strongly margined.

Abdominal sterna 1 to 4 microreticulate and densely pubescent. Sternum 1 with moderately coarse, sparse punctures apicomediaally; punctures separated by one to three times their diameter. Apical sternum pubescent along anterior and lateral margins, leaving a shiny, triangular, apicomediaal area with only a few, fine, golden setae and a few moderately coarse punctures; punctures denser apically; distinctly notched apicomediaally.

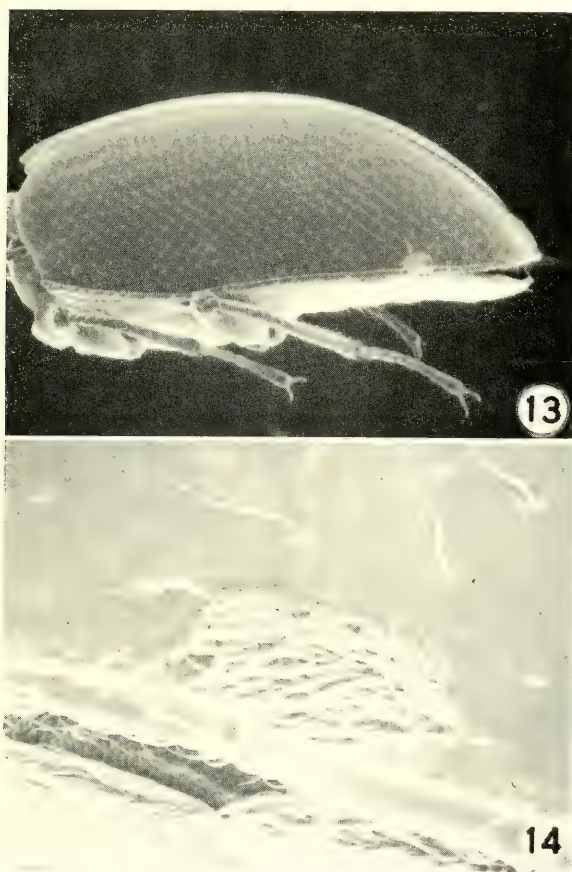
Male genitalia: As illustrated (Figs. 15, 16).

Female: Similar to male with the following exceptions: tibia of foreleg feebly arcuate and lacking the distinct notch on the inner margin at the apical fourth; first to third segments of foretarsi not expanded and



FIGS. 7-12. *Elmoparnus pandus*, new species: 7, Prosternal process, 50 \times ; 8, Apex, prosternal process, 125 \times ; 9, Mesosternal fovea, 70 \times ; 10, Protibia and protarsus, ♂, 100 \times ; 11, Foretibial notch, ♂, 160 \times ; 12, Medial surface, protarsal segments 1-3, ♂, 495 \times . All figures reduced 50 percent.

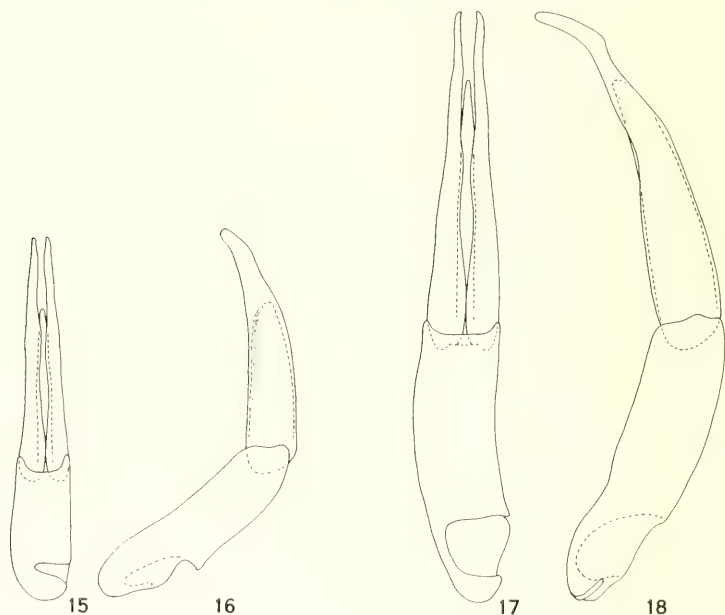
lack the large oblique row of dense, flat, golden setae on medial surface; golden setae above the glabrous liplike area of the labrum about half as long as on the males; upper edge of glabrous liplike area rounded onto the labrum instead of sharply angularly demarcated.



FIGS. 13 & 14. *Elmoparnus pandus*, new species, elytral respiratory fovea: 13, Fovea on elytron, 30 \times ; 14, Fovea, 220 \times .

Type-data: Holotype male: MEXICO: Oaxaca: Valle Nacional (4 miles south), 6 July 1974, M. E. and P. D. Perkins; USNM Type No. 73943, deposited in the National Museum of Natural History, Smithsonian Institution. Allotype, same data as holotype. Paratypes: Same data as holotype, 2♂♂, 1♀. GUATEMALA: Alta Verapaz: La Tinta (5 miles west), small tropical brook, 6 June 1974, M. E. and P. D. Perkins, 3♀♀. HONDURAS: Cortes: Puerto Cortes (5 miles south), clear tropical stream, 19 June 1974, M. E. and P. D. Perkins, 1♀.

One pair of paratypes is deposited in the P. D. Perkins collection; all other specimens are deposited with the holotype.



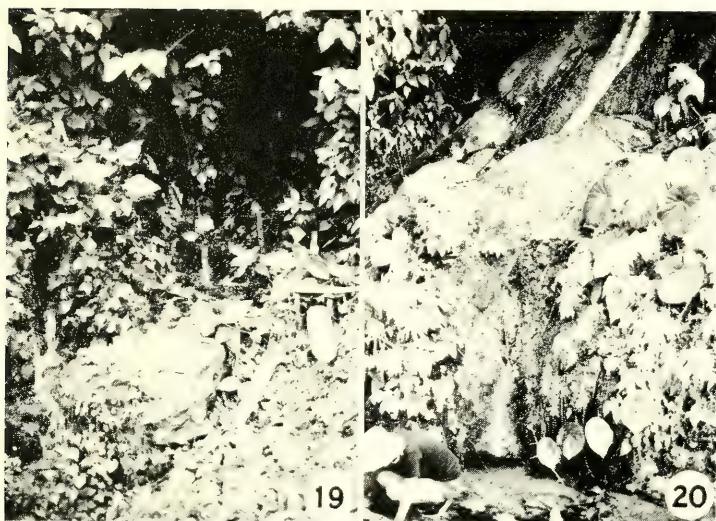
FIGS. 15-18. Male genitalia: 15-16, *Elmoparnus pandus*, new species; 15, Dorsal view; 16, Lateral view. 17-18, *Elmoparnus dasycheilus*, new species; 17, Dorsal view; 18, Lateral view.

Etymology: *pandus* from *pandus*, L.—curved, in reference to the moderately but distinctly curved foretibiae of the male and female of this species.

Habitat: Only two comments have been published concerning the habitat preference of this rare genus. Brown (1970a) mentioned that he had collected one specimen of *Elmoparnus* from a small cataract in southeastern Mexico. Later, Brown (1970b) added that this specimen, which he described as *E. mexicanus*, was found in the state of Chiapas at approximately 4,000 feet elevation.

In 1974, Perkins and his wife Maureen had the good fortune to collect this rare genus in three Central American countries: Mexico, Guatemala, and Honduras. The specimens proved to be members of the unnamed species described above as *E. pandus*.

The habitat at the type-locality, in the mountains of Oaxaca, Mexico, consisted of a small cataract flowing through the dense vegetation of a tropical rain forest (Fig. 19). The beetles were collected by removing debris, mainly twigs and leaves which had become trapped behind larger water-soaked branches, from the cataract. The debris was then placed



FIGS. 19 & 20. *Elmoparnus pandus*, new species, habitat: 19, Microhabitat at type-locality, Oaxaca, Mexico; 20, Biotope near La Tinta, Guatemala.

on a flat surface and spread out. The beetles were virtually impossible to find by inspecting each twig, but after a short wait to allow the debris to dry somewhat, specimens of *Elmoparnus* began to slowly emerge. Aquatic beetles collected in association included: Hydraenidae—*Hydraena* sp.; Hydrophilidae—*Anacaena* sp., *Enochrus* sp.; Elmidae—*Cylloepus* sp.

The biotope of *E. pandus* in Guatemala consisted of a small cataract, a portion of which was flowing over the exposed roots of a tree (Fig. 20). Although quite different in general appearance from the Oaxacan locality, the microhabitat in Guatemala was quite similar. Again, adults of *Elmoparnus* were found by removing water-soaked debris, mainly twigs, placing it on a nylon sheet, and allowing it to dry. Associated aquatic beetles included: Hydraenidae—*Hydraena* sp.; Hydrophilidae—*Notionotus* sp.

The third locality, consisting of a shallow, rapid tropical stream in Honduras, was quite different than the preceding two. A single specimen of *Elmoparnus pandus* was found while stirring up the margin of a gravel bar in midstream. The beetle, in contrast to the numerous hydrophilid specimens with which it was found, did not float to the surface when dislodged from the substratum. Other associated aquatic beetles included: Hydrophilidae—*Anacaena* sp., *Enochrus* sp.; Elmidae—*Heterelmis* sp.

Elmoparnus miltops, new species

Figure 2

This new species is similar to *E. brevicornis*, *E. pandus*, and *E. mexicanus* because all four species have 9-segmented antennae. However, the greater length (5.6 mm) of *E. mexicanus* will easily distinguish it from the other three species which are much shorter (3.1 to 3.5 mm). Both *E. miltops* and *E. pandus* may be distinguished readily from *E. brevicornis* by the sublateral carina extending from base to apex instead of being restricted to the basal two-fifths as it is in *E. brevicornis*. From *E. pandus*, which it most closely resembles, *E. miltops* may be distinguished by the form and sculpture of the anteromedial region of the metasternum which is wider, distinctly elevated, and possesses coarse, sometimes confluent punctures (Fig. 2) instead of being narrow, weakly elevated, and with small widely separated punctures (Fig. 1). In addition, the posterior coxae of *E. miltops* are more densely and coarsely punctate than the posterior coxae of *E. pandus*.

Holotype female: Length 3.4 mm; width 1.7 mm. Body form obovate, moderately strongly convex dorsally. Color black dorsally except antennae, clypeus, and labrum light reddish brown. Venter black with reddish tinge except all palpi, labium, apical margin of prosternum, tibiae, tarsi, and apex of last abdominal sternum lighter reddish brown.

Head finely microreticulate and densely pubescent except anterior edge of clypeus glabrous. Eyes with large convex facets also pubescent. Antenna 9 segmented. Labrum shallowly emarginate anteromedially; emargination bordered by a glabrous liplike area; upper edge of liplike area is rounded onto labrum instead of being sharply demarcated; labral surface above liplike area densely microreticulate, with numerous short, scattered, golden setae and a few long golden setae; anterolateral angles broadly rounded.

Pronotum 1.0 mm long; 1.5 mm wide, widest at base; sides arcuate; anterior side feebly margined; lateral sides strongly and distinctly margined; posterior side not margined but strongly bisinuate; anterolateral angles strongly produced, apex acute; sublateral carinae distinct, extending from base almost to apex at each anterolateral angle; diverging so that each carina is only about one-half as far from lateral margins as at base; coarse and fine punctures intermixed and denser between sublateral carina and lateral margin. Pronotal disc with coarse (at 100 \times) moderately dense punctures; punctures separated by their diameter; punctures coarser and sparser adjacent to sublateral carina. Prosternum with inclined sides densely pubescent; medial surface flat, glabrous, and coarsely sparsely punctate; punctures denser along apical margin and separated by one-half to one times their diameter. Prosternal process flat, broad, widening slightly between procoxae; sides feebly margined, arcuate, and converging apically; terminating in a slender protuberance; surface glabrous, sparsely and moderately coarsely punctate; punctures separated by two to three times their diameter, denser and coarser laterally. Meso-

sternum deeply foveate for reception of protuberance of prosternal process. Metasternum with anteromedial region broad, moderately but distinctly raised above plane of posterior region (Fig. 2); inclined sides densely pubescent; medial surface flat, almost glabrous, punctate, with fine shallow longitudinal furrow on midline; punctures moderately coarse and sparse along furrow but some very coarse and some confluent punctures anteromedially (Fig. 2). Metacoxa densely, coarsely punctate. Foretibiae evenly arcuate from base to apex.

Scutellum flat, subtriangular, rounded laterally; surface finely sparsely punctate, punctures separated by a distance about three to four times their diameter.

Elytra punctate. Punctures coarser and denser than those on pronotal disc; disc with coarse punctures adjacent to suture in poorly defined rows, punctures separated by one-half to two times their diameter. Lateral margin of each elytron with a densely pubescent respiratory fovea at about apical fourth. Sides of elytra rather evenly arcuate from base to apex; sides rather strongly margined.

Abdominal sterna 1 to 4 densely pubescent. Sternum 1 with moderately fine, sparse punctures anteromedially; punctures separated by one to three times their diameter. Apical sternum densely pubescent along anterior and lateral margins leaving a shiny, triangular, apicomедial area with only a few, fine, golden setae and a few moderately coarse punctures; punctures denser apically; distinctly notched apicomедially.

Male: Unknown.

Type-data: Holotype female; ECUADOR: Zamora-Chinchipe: Zamora, 9 June 1976, Andrea Langley et al.; USNM Type No. 73944, deposited in the National Museum of Natural History, Smithsonian Institution.

Etymology: *miltops*, from *miltos*, G.—red, plus *ops*, G.—face, in reference to the reddish labrum and clypeus of the species.

Habitat: The single female specimen was collected about 1 km from Zamora on the Zamora-Gualaquiza road in a small pool in a roadside drainage ditch. The partially shaded ditch was fed by tiny rills flowing down from the mountainside. Trichoptera larvae were collected along with the holotype indicating a lotic habitat.

***Elmoparnus dasycheilus*, new species**

Figures 6, 17, 18

This new species is similar to *Elmoparnus glaber* Grouvelle, the only other species in the genus with 10-segmented antennae. From *E. glaber*, this new species may be distinguished by the flat instead of deeply grooved prosternal process.

Holotype male: Length 4.9 mm; width 2.4 mm. Body form obovate, moderately strongly convex dorsally. Color black dorsally except antennae, eyes, and labrum reddish brown; pronotum and elytra virtually glabrous; head not shining black like pronotum and elytra because of dense golden setae and microreticulate surface. Venter black except all

palpi, labium, apical margin of pronotum, tibiae, tarsi, and apex of last abdominal sternum reddish brown.

Head finely microreticulate and densely pubescent except anterior edge of clypeus which is glabrous; eyes with large convex facets also pubescent. Antennae 10 segmented (Fig. 6). Labrum moderately emarginate anteromedially; emargination bordered by a glabrous liplike area; upper edge of liplike area sharply, angularly demarcated; labral surface above liplike area densely microreticulate and provided with long, golden upswept setae dorsolaterally resembling a mustache; anterolateral angles broadly rounded.

Pronotum 1.3 mm long, 1.8 mm wide; widest across basal fourth; side arcuate; anterior and lateral sides distinctly margined; posterior side not margined but strongly bisinuate; anterolateral angles strongly produced, apex blunt; sublateral carinae distinct, extending from base almost to apex at each anterolateral angle; diverging so that each carina is only about one-half as far from lateral margins as at base. Coarse and fine punctures intermixed and sparse between sublateral carina and lateral margin. Disc with coarse (at $100\times$), moderately dense punctures; punctures separated by a distance about twice their diameter; punctures coarse and fine intermixed and denser laterally. Prosternum with inclined sides densely pubescent; medial surface flat, glabrous, and rather finely sparsely punctate; punctures denser along anterior margin and separated by a distance one-half to one times their diameter. Prosternal process flat, widening slightly between procoxae; sides feebly margined, arcuate, converging apically and terminating in a slender protuberance; surface glabrous, and sparsely, moderately coarsely punctate; punctures separated by three to eight times their diameter. Mesosternum deeply foveate for reception of protuberance of prosternal process. Metasternum with inclined sides densely pubescent; medial surface flat, glabrous, with shallow longitudinal furrow on midline, and punctate; punctures moderately coarse, moderately sparse along furrow but dense, slightly rugose anteromedially between mesocoxae. Foreleg with tibia curved, abruptly bent at apical fourth; bearing a sparse, narrow tuft of moderately long golden setae along posteromedial edge; tuft extends distad about one-half length of tibia. Protarsal segments 1 to 3 expanded and bearing a large oblique row of dense, flat, golden setae on medial surface.

Scutellum flat, subtriangular, rounded laterally; surface finely, sparsely punctate; punctures separated by a distance almost four to six times their diameter.

Elytra punctate; punctures moderately coarse, slightly smaller and varying more in size than those on pronotal disc; punctures on disc separated by a distance two to six times their diameter; each puncture bearing a microseta; lateral margin of each elytron with a densely pubescent respiratory fovea at about apical fourth. Sides of elytra diverging to basal fifth then feebly angulate and thereafter arcuate and converging very gradually to apices; sides strongly margined.

Abdominal sterna 1 to 4 microreticulate and densely pubescent. Apical

sternum with dense pubescence along anterior and lateral margins leaving a shiny, triangular, apicomedial area with only a few, fine, golden setae and a few coarse punctures; punctures denser apically; distinctly notched apicomediaally.

Male genitalia as illustrated (Figs. 17, 18).

Female: Similar to male with the following exceptions: tibia of fore-leg feebly arcuate and lacking the moderately abrupt bend at the apical fourth; first to third segments of foretarsi are not expanded and lack the large oblique row of dense, flat, golden setae on medial surface; golden setae above the glabrous liplike area of the labrum are about one-half as long on both females of the type-series as on the male; upper edge of the glabrous liplike area rounded onto the labrum instead of sharply, angularly demarcated.

Type-data: Holotype male; ECUADOR: Pastaza: Tarqui, 10 February 1976, Spangler et al.; USNM Type No. 73954, deposited in the National Museum of Natural History, Smithsonian Institution. Allotype, same data as holotype. Paratype, same data as holotype, 1♀.

Etymology: *dasycheilus*, from dasy, G.—hairy, plus *cheilus* from cheilos, G.—lip, in reference to the very long golden fringe of setae on the labrum which is especially obvious on the male.

Habitat: Collected from leaves and twigs drifted against rocks in a very small stream, which was well shaded by dense overhanging vegetation.

RESPIRATION

Perkins collected and observed specimens of *E. pandus* at the type-locality and his observations are given below along with a general discussion of the unique morphological adaptations for respiration in the genus *Elmoparnus*.

Specimens of *E. pandus*, collected at the type-locality, were placed in a vial containing water and a few small twigs. When viewed with a microscope, the beetles were seen to periodically crawl up the twigs to a position just below the surface of the water. The beetles then would bring their antennae forward so that the air layer surrounding one antenna became contiguous with the air layer surrounding the other. Each antenna was slightly arched, resulting in a small separation of the apical segments of one antenna from the apical segments of the other (Fig. 3). The beetles would then move toward the surface of the water and break the surface film with the antennae. After remaining in this position for a short time, the beetles would turn and crawl downward on the twig.

Apparently respiration in *Elmoparnus* is accomplished as follows. Contact is made with atmospheric air by the antennae which are covered with hydrofuge pubescence; thus a thin layer of air surrounds the antennal segments. Each antenna, when held next to the head, lies beneath a large tuft of hairs. These hairs plus others on the head also constitute hydrofuge pubescence and result in the head, with the exception of the

palpi and a portion of the labrum, being surrounded by a layer of air. Therefore, oxygen-rich atmospheric air is transmitted from the surface of the water by way of the hydrofuge pubescence on the antennae to the head and then to the ventral bubble where respiration takes place.

The function of the antennae in respiration in *Elmoparnus* is unique among the known Dryopidae. Most dryopids have dense hydrofuge hairs on the dorsal surface, but the antennae do not function to replenish the air supply as they do in *Elmoparnus*. The other known dryopids have a plastron which maintains a thin layer of air against a pressure differential (Thorpe, 1950). This allows the beetles to obtain oxygen directly from the water, thus obviating the necessity of contacting atmospheric air. As a result, these dryopids, although they cannot swim, are able to utilize habitats far beneath the surface of deep streams and rivers. However, *Elmoparnus*, which also cannot swim, must remain near the surface of the water to obtain atmospheric air, and this may partially explain why most specimens of *Elmoparnus* have been collected from cascades and small brooks where the water is relatively shallow.

Many aquatic beetles, most notably the Hydraenidae and Hydrophilidae, use the antennae to form an air funnel between the atmospheric air and the air reservoir which is held by hydrofuge pubescence to the venter. The antennae of hydraenids and hydrophilids are inserted on the lateral areas of the head and function independently for air replenishment. This lateral placement of the antennae allows the hydraenids and hydrophilids to obtain air when either side of the body or the dorsum of the head is close to the surface of the water.

In marked contrast, the antennae of *Elmoparnus* are inserted near the midregion of the head and do not function independently; therefore *Elmoparnus* apparently can use the antennae to obtain air only when the dorsum of the head is close to the surface of the water. If this is true, certain restrictions would be imposed on the activity of the beetles. Beetles which are feeding in a head downward position would have to periodically interrupt the feeding process to return to the surface to replenish the air supply. These supposed restrictions may explain the unusual, densely pubescent respiratory fovea on the lateral elytral margin of all known species of *Elmoparnus* (Figs. 13, 14). This respiratory fovea is not found on any other known Dryopidae (Hinton, 1940). Observations on living, submerged beetles have shown that the respiratory fovea holds a small bubble of air which is connected to the ventral bubble by a narrow, pubescent channel.

The respiratory foveae may have evolved to allow *Elmoparnus* to obtain atmospheric air when the beetle is oriented with its side close to the surface of the water and when in a head downward position. If this is the case, *Elmoparnus* would be capable of feeding in a head downward position without the necessity of periodically stopping to obtain air. Further observations are needed to confirm this hypothesis because such behavior was not witnessed. (The observation vials contained only twigs of small diameters and these were placed at approxi-

mately a 45 degree angle to the surface of the water. Further studies might involve horizontal twigs placed just below the surface.)

DISCUSSION

Previous accounts of the morphology, habitats, and behavior of the species of *Elmoparnus* have been understandably brief and incomplete or lacking because of the rarity of specimens for study and observation. Our examination of both sexes and of a greater number of specimens than were previously available, as well as observations of living specimens of *E. pandus*, has added materially to our knowledge of the morphology and behavior of the species of *Elmoparnus*. However, the males of *mexicanus* and *mitops* are still unknown and further observations on living material are needed to confirm or refute some of the ideas we express regarding certain aspects of their respiratory behavior, e.g., firsthand observations on the use of the respiratory fovea on each elytron.

Hinton (1940), in his redescription of Sharp's type, mentions the presence of the long labral setae on the male holotype of *E. brevicornis*. This appears to be a characteristic of the males of all of the species of *Elmoparnus*. At least we now can confirm that males of *E. brevicornis*, *E. glaber*, *E. dasycheilus*, and *E. pandus* have the long labral setae. In addition the males of *E. glaber*, *E. dasycheilus*, and *E. pandus* have the following characters in common: protarsal segments 1 to 3 distinctly expanded and provided with oblique rows of flat, dense, golden setae; and a rather distinct bend or an obvious notch present at the apical fourth of the protibia. We believe these secondary sexual modifications of the males will be present on the males of *E. mexicanus* when they are found. No mention is made of a tuft of longer setae on the protibiae, expanded protarsi, or distinct bend or notch at the apical fourth of the protibia for *E. brevicornis* by Hinton (1940). If Hinton's habitus illustration of *E. brevicornis* was drawn from Sharp's male holotype, it apparently lacks the expanded protarsi and notch or obvious bend at apical fourth of the protibia mentioned above. We have not seen Sharp's unique male type.

The glabrous dorsal surface of the species of *Elmoparnus* may be an adaptation which decreases resistance to the flow of water, thereby allowing these insects to utilize habitats with fast currents such as cascades. However, the slick surface may present problems during copulation, because the male could be easily dislodged from the female by a fast current. Apparently the species of *Elmoparnus* have solved this problem in a manner similar to certain hydraenids and hydrophilids—by increasing the adhering abilities of the male protarsi. This is accomplished by an expansion of the first three protarsal segments and modification of the setae to form comblike structures (Figs. 10, 11, 12). In addition, the well-developed notch of the protibia (Fig. 11) of the male *E. pandus*, and the obvious bend of the protibia of males of other species at its apical fourth probably aids in firmly grasping the female. The pro-

tarsi of the males of the known species of *Elmoparnus* are quite unlike those of other described dryopids because the others lack the expanded protarsal segments and the modified setae.

In Hinton's (1940) redescription of Sharp's *E. brevicornis* he illustrated the prosternal process and showed it terminating in a slender protuberance. Later, when Brown (1970) described *E. mexicanus*, he also illustrated the prosternal process of his new species but he illustrated it as without an apical protuberance and used this as a character in his key to separate *E. mexicanus* from *E. glaber*. However, all specimens of all species we have examined have the apical protuberance on the prosternal process and we believe it is present on *E. mexicanus* too. The reason Brown probably overlooked the protuberance is easily explained because in its normal position the protuberance (Figs. 7, 8) fits compactly into a deep fovea (Fig. 9) in the mesosternum. In order to see the protuberance, the prosternal process must be disarticulated from the mesosternum.

The first species known, *E. brevicornis* described by Sharp in 1882, is still known only from the type-specimen and the one additional specimen from Panama reported by Hinton in 1940. The second species discovered, *E. glaber*, described by Grouvelle in 1889, was known only by the type-series until this year when Dr. Oliver S. Flint, Jr., and his wife Carol collected the following specimens. Venezuela: Merida: Merida (27 km W, on Rt. 4), 20 Feb. 1976, 2 ♂♂, 2 ♀♀. Venezuela: Aragua: Rancho Grande (4 km S), 5 Feb. 1976, 1 ♀. The third species known, *E. mexicanus* described by Brown in 1970, is known only from the type-specimen.

Obviously specimens of *Elmoparnus* are rare in collections and special efforts must be made by collectors to find them. Frequent lighttrap collections made over a 2-year period in Ecuador failed to attract a single specimen of *Elmoparnus*; therefore, we doubt that they will be collected by this method. Hand sorting through sticks, leaves, and similar debris caught against rocks and logs in small streams and cascades as discussed under the descriptions of the new species of *Elmoparnus* seems to be the most practical and productive way to collect these elusive beetles.

Of the six species of *Elmoparnus* now known, four have 9-segmented antennae. One of these species, *E. mexicanus*, is known only from Mexico; one species, *E. pandus*, is known from Mexico and Central America; the third species, *E. brevicornis*, is known from Central America; and the fourth species, *E. miltops*, is known from South America. The two known species with 10-segmented antennae, *E. glaber* and *E. dasycheilus*, are known only from South America. The six species of *Elmoparnus* may be distinguished by use of the following key.

KEY TO THE SPECIES OF *ELMOPARNUS*

1. Sublateral carina confined to basal two-fifths of pronotum; antenna 9 segmented; Panama *E. brevicornis* Sharp

- Sublateral carina extending nearly entire length of pronotum; antennae 9 or 10 segmented 2
2. Antennae of 9 segments 3
- Antennae of 10 segments 5
3. Length about 5.6 mm; clypeus black; Mexico *E. mexicanus* Brown
Length 3.4 mm to 3.5 mm; clypeus reddish brown; Mexico, Central America, and South America 4
4. Anteromedial region of metasternum narrow, very slightly or not at all raised above plane of posterior portion of metasternum, and bearing small sparse punctures (Fig. 1); hind coxae sparsely and moderately coarsely punctate; Mexico and Central America *E. pandus*, new species
- Anteromedial region of metasternum wide, raised above plane of posterior portion of metasternum, and bearing large, frequently confluent punctures (Fig. 2); hind coxae densely and coarsely punctate; Ecuador *E. miltops*, new species
5. Middle of prosternal process rather deeply longitudinally grooved; Venezuela *E. glaber* Grouvelle
- Middle of prosternal process flat; Ecuador *E. dasycheilus*, new species

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